Chapter 8

THE FRAMEWORK: STANDARDS 6-12

(The Process Standards)

Standard 6: Organisms
Standard 7: The Diversity of Life
Standard 8: Structure and Behavior of Matter
Standard 9: Matter, Forces, and Energy Transformations
Standard 10: Earth Systems
Standard 11: The Universe
Standard 12: The Environment

SCIENCE STANDARD 6

All students will gain an understanding of the structure, characteristics, and basic needs of organisms.

INTRODUCTION

This standard serves as a scaffolding on which students build their biological understanding of life. The interdependence of living things is a major focus. To achieve this standard, students determine the characteristics that are unique to life. These common processes are displayed in the wide variety of life on Earth. Although tremendous variation exists among living things, students should understand that individual organisms are part of a larger system. As part of this system, living things depend on each other.

Within individual living things, structure is related to function. This relationship is even displayed on the cellular level. Students should understand that multicellular organisms are composed of interacting components such as tissues and organs.

This standard emphasizes the flow of energy as a common theme that is encountered at the level of cells, organisms, and ecosystems. A cell's energy producing and consuming activities are controlled by specific molecules. The reciprocal relationship between photosynthesis and respiration establishes the interdependence of the life cycles interacting within an ecosystem.

DEVELOPMENTAL OVERVIEW

In grades K-2, children begin to recognize the uniqueness of life by investigating the characteristics of living and nonliving things. In grades 3-4, activities challenge students' misconceptions about the characteristics of life. They realize that some nonliving things can act as though they are alive! In the intermediate grades, students not only determine the differences between living and nonliving things (grades 5-6), but also begin to describe the major categories of plants and animals (grades 7-8). At the high school level (grades 9-12), students use the presence of cells and DNA as indicators of life.

The relationship between structure and function is introduced in primary grades (K-4) through the use of concrete examples. This concept is expanded to increasingly abstract levels until high school, where students are challenged by structure and function at the molecular level.

The investigation of interdependence, the flow of energy, and life cycles begins in grades K-2 with observations. In grades 3-4, children recognize the existence of a food chain, and they participate in activities that describe the roles of different organisms in a food chain. In grades 5 or 6, students begin to explore ecosystems. More sophisticated studies of interdependence begin in grades 7 or 8 by evaluating the influence of the nonliving environment on an ecosystem. At the high school level, students investigate the energy interdependence of living things at the biochemical level. The relationship between photosynthesis and respiration is established in terms of energy conversion.

DESCRIPTIVE STATEMENT

The study of science must include the diversity, complexity, and interdependence of life on Earth. Students should know how organisms evolve, reproduce, and adapt to their environments. Standard 6 (originally called “5.6”) and Standard 7 (“5.7”) serve to define the fundamental understandings of the life sciences.

CUMULATIVE PROGRESS INDICATORS

By the end of Grade 4, students

1. Compare and contrast living and nonliving things.
2. Determine the basic needs of organisms.
3. Show that living things have different levels of organization.
4. Show that plants and animals are composed of different parts serving different purposes and working together for the well-being of the organism.
5. Describe life cycles of organisms.
6. Group organisms according to the functions they serve in a food chain.
7. Identify the major systems of the human body and explain how their functions are interrelated.

Building upon knowledge and skills gained in the preceding grades, by the end of Grade 8, students

8. Describe and give examples of the major categories of living organisms and of the characteristics shared by organisms.
9. Recognize that complex multicellular organisms are interacting systems of cells, tissues, and organs.
10. Identify and describe the structure and function of cell parts.

11. Explain how organisms are affected by different components of an ecosystem and the flow of energy through it.

12. Illustrate and explain life cycles of organisms.

Building upon knowledge and skills gained in the preceding grades, by the end of Grade 12, students

13. Identify and describe organisms that possess characteristics of living and nonliving things.

14. Identify and explain the structure and function of molecules that control cellular activities.

15. Explain how plants convert light energy to chemical energy.

16. Describe how plants produce substances high in energy content that become the primary source of energy for animal life.

17. Compare and contrast the life cycles of living things as they interact with ecosystems.

LIST OF LEARNING ACTIVITIES FOR STANDARD 6

GRADES K-4

Indicator 1:

GRADES K-2
Is It Alive?
Check It Out!
Take a Hike!

GRADES 3-4
Are Raisins Alive?
Scavenger Hunt!
Hay Infusion

Indicator 2:

GRADES K-2
[no activities]

GRADES 3-4
Fish Watching
Critter Watching, continued
Ant Feeding
Mold Growing
Egg Hatching

Indicator 3:

GRADES K-4
Ant Farm Cooperation

GRADES K-2
Beehive Business
More Role Play

GRADES 3-4
Social Organization, continued
Animal Homes
Embryonic Development

Indicator 4:

GRADES K-2
Aquatic Adaptations
Invent the Animal!
Create a Dinosaur!

GRADES 3-4
[no activities]

Indicator 5:

GRADES K-2
Teddy Bears and Their Homes

GRADES 3-4
Composting
Growing "Fast Plants"
Critter Watching

Indicator 6:

GRADES K-2
Fly Away Home!
Outdoor Rot
Indoor Rot

Grades 3-4
Constructing Food Webs
Observing Food Chains

Indicator 7:

GRADES K-4
Fasten Seat Belts!
The Nervous System

GRADES K-2
Smelling
Hearing
Touching

GRADES 3-4
The Circulatory System
The Digestive System
The Respiratory System
The Immune System

GRADES 5-8

Indicator 8:

GRADES 5-6
Field Trip!
Tree/Leaf Identification

GRADES 7-8
Classifying
Animal and Plant Diversity
Plant and Animal Characteristics

Indicator 9:

GRADES 5-6
System Components
Multimedia Investigations

GRADES 7-8
Images of the Hierarchy
Multimedia Investigations
Biosphere Components

Indicator 10:

Grades 5-6
Leaf Model

Grades 7-8
Analogies
Time Line
Cell Model

Indicator 11:

GRADES 5-6
Ecosystem Research
Ecosystem Simulations

GRADES 7-8
Environmental Factors
Population Studies
Energy Flow

Indicator 12:

GRADES 5-6

Mealworm Life Cycle
Bird Life Cycle

GRADES 7-8

Human Life Cycle
Frog Life Cycle
Butterfly Life Cycle
Plant Life Cycles
Career Exploration

GRADES 9-12

Indicator 13:

Respiration and Growth Investigations
Pond-Water Life
Viruses and Technology
Viruses and Health

Indicator 14:

Modeling Organic Nutrients
Testing for Organic Nutrients
Testing Enzyme Activity

Indicator 15:

Investigating Photosynthesis

Indicator 16:

Illustrating Plant/Animal Interdependence
Investigating the Photosynthesis/Respiration Connection

Indicator 17:

Effect of Environmental Factors on Germinating Seeds
Fallen Leaves and Invertebrate Populations

Indicator 1: Compare and contrast living and nonliving things.

LEARNING ACTIVITIES: Grades K-2

Is It Alive? Students compare a live fish with a picture of a fish. Are they both fish? How are they the same? How are they different? Students identify what it is that makes the fish alive. If their response is "motion," a wind-up toy might challenge their thinking. If their response is "reacts to touch," a toy that changes direction when it makes contact can cause them to rethink their answer. Encourage students to wonder out loud.

Check It Out! Students can help set up aquariums or terrariums, in which they raise many different kinds of plants and animals. They can record their observations in picture logs and journals. Over time, students will start to form ideas and conceptions about living versus nonliving.

Take a Hike! During exploratory walks outside, students can look for both living and nonliving things.

Supporting Educational Research: *Benchmarks*, p. 103 (5A)
Related Science Standard: 1
Related Workplace Readiness Standards: 3.7, 4.2, 4.4

LEARNING ACTIVITIES: Grades 3-4

Are Raisins Alive? Students first pour several ounces of a clear carbonated drink in two clear plastic or glass cups. They drop a few raisins in one cup and a few frozen grapes in the other. The students then make observations regarding the "life" of these items. Are they giving off a gas? Are they moving on their own? Are they growing? What observations might convince the students that the raisins and grapes are living things? What evidence do the students find that indicates they aren't?

Scavenger Hunt! A simple scavenger hunt for feathers, leaves, bones, rocks, paper clips, etc., can enhance the living-versus-nonliving issue. After collecting the items, the students can then classify them.

Hay Infusion. Create a hay infusion in pond water. Within a few days, organisms will begin to appear at various levels. Students may need a microscope to see some of them. Many centuries ago, some people believed that living things occurred directly from dead things—a good topic for discussion.

Supporting Educational Research: *Benchmarks*, p. 341 (5A)
Related Science Standard: 1
Related Workplace Readiness Standards: 3.1, 3.2, 3.12

Indicator 2: Determine the basic needs of organisms.

LEARNING ACTIVITIES: Grades 3-4

Fish Watching. As students observe fish behavior, they make notes regarding the ways fish move, get food, defecate, and solve all their problems of living. As students study the behaviors associated with a fish, they can attempt to answer questions such as the following: Do fish drink? Do fish sleep? Do fish know their own young? Older students can map fish movements.

Critter Watching, continued. As an enhancement activity, each student can raise a small critter at his/her desk. Good candidates include mealworms, crickets, ladybugs, and butterflies. This activity sparks interest and permits students to closely observe animal behavior, which can later be compared with that of larger organisms such as mice or pets.

Ant Feeding. Students can determine which food ants prefer by finding an ant hill outdoors and placing a small spoonful of tuna, cat food, or meat scraps about one foot away from it. At a different location, students put honey, syrup, or fruit. Students then record their observations and discuss the preference they observe.

Mold Growing. Raising molds inside plastic bags allows students to closely examine their specimen yet avoids allergy problems. Students can list favorable conditions for mold growth and design experiments. They can assemble mold gardens and compare rates and duration of growth with soil vs. without soil, in cool vs. warm places, wet vs. dry places, and light vs. dark places. They should observe completed cycles and keep good records.

Egg Hatching. As an enhancement activity, the students can try to hatch eggs obtained from a private hatchery. Be sure homes are available for the hatchlings (required by law). Hatching brine shrimp in a classroom aquarium is another possibility.

Supporting Educational Research: *Benchmarks,* p. 116 (5D)
Related Science Standards: 1, 2
Related Workplace Readiness Standards: 1.9, 3.2, 3.7

Indicator 3: Show that living things have different levels of organization.

LEARNING ACTIVITY: Grades K-4

Ant Farm Cooperation. An ant farm can help students identify the division of labor that occurs with colonial animals. Supplementing with videos or laser discs will enable the students to see additional aspects that are not readily viewable.

LEARNING ACTIVITIES: Grades K-2

Beehive Business. Through role playing, children act out each of the different jobs performed by members of a beehive. Use fragrances to put scents only on certain members and not on others. Through their sense of smell, student bees try to figure out which bee is not from their hive. Students can perform a "bee dance" to help other bees find the flowers with the nectar.

More Role Play. Penguins, ladybugs, and ants are other possible animals that can be used for role play.

LEARNING ACTIVITIES: Grades 3-4

Social Organization, continued. Students compare and contrast the level of social organizations among people and other organizations.

Animal Homes. Students can investigate different biomes and animal habitats as well as the dwellings of animals that allow them to survive in their particular environments.

Embryonic Development. Starting with fertilized frog eggs, students discuss the changes in organization that occur as an egg develops. They then compare frog development with the development of other animals, including chicks and humans.

Supporting Educational Research: *Benchmarks,* pp. 111 (5C), 116 (5D)
Related Science Standards: 1, 2
Related Workplace Readiness Standards: 3.1, 3.2, 3.5, 3.7, 4.2, 4.7, 4.9, 5.6

Indicator 4: Show that plants and animals are composed of different parts serving different purposes and working together for the well-being of the organism.

LEARNING ACTIVITIES: Grades K-2

Aquatic Adaptations. How are fish adapted to life in the water? While studying fish in an aquarium, students figure out how each fin functions in the movement of the fish. They decide how the location and the structure of each fin contributes to its functions. Besides fins, how else is a fish adapted to life in the water? How does a fish eat? Does it drink the water? Videos, laser disc programs, guest speakers, and a trip to the library can supplement the classroom investigations.

Invent the Animal! Students create an animal or plant that can survive under a certain set of circumstances. An example would be: "What plant or animal could survive living in a mowed lawn?" Low-growing plants and burrowing animals would be best suited because they would not be injured by the mowing. Given pictures of butterflies or fish, students design backgrounds or shapes that allow the animal to be "hidden."

Create a Dinosaur! Show students a picture of a ferocious dinosaur. (Avoid T. Rex because it has recently been labeled a scavenger.) Students identify the parts of the body that were used for protection, movement, and feeding. Give students pictures of simple "bare-bones" dinosaurs and ask them to add pieces to the image that would add protection or aid in movement.

Supporting Educational Research: *Benchmarks*, p. 103 (5A)
Related Science Standards: 1, 2
Related Workplace Readiness Standards: 1.5, 3.2, 3.3

Indicator 5: Describe the life cycles of organisms.

LEARNING ACTIVITY: Grades K-2

Teddy Bears and Their Homes. There is a basic need among animals for a home. For some, a specific spot is a home, but for others, a big territory is required. This activity helps students examine the issues of a specific home and how it impacts their survival.

Students bring to class as many teddy bears as possible regardless of size. Supply the students with cardboard boxes (and lids) in a variety of sizes. Students can cut a small hole in the side of the small boxes and openings of different sizes on the larger boxes. The students then try to put their teddy bears into the boxes. Which teddy bears fit? How many can fit in a box? Which bears can enter more boxes than others? What happens to the bears that do not fit inside any of the homes? What happens when too many teddy bears get inside a single box? What happens if enemies get into a box with the bears?

Supporting Educational Research: *Benchmarks,* p. 119 (5E)
Related Science Standards: 1, 2
Related Workplace Readiness Standards: 3.2, 3.6, 5.6

LEARNING ACTIVITIES: Grades 3-4

Composting. After setting up a compost pile, students can study what animals grow in it, how fast they grow, and what happens to the material that the students originally placed in the pile. Older students can do population studies within this community.

Growing "Fast Plants." Obtain seeds of "fast plants" from a commercial biological supplier. (Fast plants are critical if the whole life cycle is to be observed.) Students can experiment to determine what conditions are best. Young students can discuss what they think plants need to grow and set up the activities that they are curious about. Older students can set up what they consider to be control experiments. The class can hold a contest to see who can grow the tallest plant.

Critter Watching. By raising mealworms, earthworms, or crickets, students can see a critter's entire life cycle. Older students can design experiments to study light-sensitivity behavior, color preferences, food preferences, and maze crawling. After recording results, students can share conclusions and discuss variables.

Supporting Educational Research: *Benchmarks,* pp. 119 (5E), 123 (5F)
Related Science Standards: 1, 2, 5
Related Workplace Readiness Standards: 3.2, 3.4, 3.6

Indicator 6: Group organisms according to the function they serve in the food chain.

LEARNING ACTIVITIES: Grades K-2

Fly Away Home! The ladybug can serve as an excellent example of an insect filling a niche. Students discover how a ladybug scares away predators by observing them with a hand lens and conducting simple experiments with aphids and other plant pests. Students recognize how the ladybug fits into the food chain as they observe the foul secretion from its legs and the "after-dinner cleanup."

Outdoor Rot. Students can discuss decomposers and their role in various food chains. If possible, the students go for a walk outdoors looking for evidence of decomposition.

Indoor Rot. Take a clean container and make a mini-terrarium. Students can observe changes through its clear sides. Recording the changes on a regular basis will help the students determine what happens to the items they placed inside. The students can choose an assortment of items (e.g., food, leather, and paper) to place inside and keep moist.

Supporting Educational Research: *Benchmarks,* p. 123 (5F)
Related Science Standards: 1, 2
Related Workplace Readiness Standards: 3.1, 3.2, 3.6

LEARNING ACTIVITIES: Grades 3-4

Constructing Food Webs. With this activity, the class can simulate the relationships within a food chain. Each student picks an index card with the name of a plant or animal printed on it. The students toss differently colored balls of yarn to those students representing the organisms on which they can feed. Actual food chains and food webs become visible as the yarn balls get passed around from organism to organism. Students can discuss the roles of herbivores, carnivores, and omnivores. The number of links can be used to determine each organism's importance in the food chain. Students predict what will occur as organisms are randomly selected for extinction.

Observing Food Chains. Aquariums and terrariums provide excellent visual examples of the food chains within a community—as long as a variety of organisms is used. Encourage students to make regular observations and maintain a journal in which they record changes in diversity and the size of populations.

Supporting Educational Research: *Benchmarks,* p. 116 (5D)
Related Science Standards: 1, 2
Related Workplace Readiness Standards: 3.1, 3.2, 3.6

Indicator 7: Identify the major systems of the human body and explain how their functions are interrelated.

LEARNING ACTIVITIES: Grades K-4

Fasten Seat Belts! To prepare students for the study of the human body, read the book *The Magic School Bus Inside the Human Body*. Students trace an outline of their body on a large sheet of paper and indicate where the various parts are located inside. Using other paper, students cut out representative parts of each system and attach them to the appropriate location in their body outline. There are excellent videos and published activities to help students in their study of human anatomy and physiology.

The Nervous System. These few simple activities can demonstrate the functions of the human nervous system.

- Try testing students' hearing from different positions to see when the body detects the direction of sound best.
- What colors seem to cause the eye confusion? By examining optical illusions, students can see how the eye and brain must work together to interpret images.
- Students can determine their skin's sensitivity to touch by using toothpicks at varying distances of contact.

Eye-hand coordination can be tested by dropping a meterstick vertically from a low height and having students catch it as it falls. Students measure the point at which they catch the stick and compare the catch point over a number of trials. How is the nervous system, skeletal system, and muscle system working as a team? Why does reaction improve with trials?

LEARNING ACTIVITIES: Grades K-2

Smelling. Students try to identify the smells from certain unmarked bottles. Discuss the dangers of smelling unknown materials.

Hearing. Make a tape recording of common school sounds. Students identify each sound.

Touching. Students identify a variety of objects in a touch box.

LEARNING ACTIVITIES: Grades 3-4

The Circulatory System. Students discuss the heartbeat and how a pulse is created. They then take their own pulse at the neck (carotid pulse) by counting the number of beats in 15 seconds under various conditions (e.g., lying down, standing, and exercising). Will just wiggling their toes change the heart rate? What conditions or factors change the heart rate as measured by the pulse?

The Digestive System. This simple activity can demonstrate one of the functions of the human digestive system. The digestive system can be modeled by using a pair of old pantyhose. Students sew the waistband closed to form the stomach. They take one leg and cut off the toes to form a long piece of intestine. They create an esophagus by cutting the other leg so that just a six-inch (15-cm) piece remains attached to the panty. To simulate peristalsis, students place a wad of cotton in the esophagus and see the stretching and pushing that's necessary to get it into the stomach. Why is the stomach so wide compared to the rest of the tube? What happens in the stomach?

The Respiratory System. These two simple activities can demonstrate the functions of the human respiratory system.

- Students study the respiratory system by using a soda bottle filled with water, a piece of rubber tubing, and a masking-tape marker indicating specific volumes on the outside. They turn the filled soda bottle upside down in a washtub with the tube going up into the mouth of the bottle. The students exhale into the tube until they are out of air. They then measure the air on the side of the bottle to determine each student's lung capacity. Do all students have the same lung capacity? What factors can affect the volume?

- Students use a simple bell jar to demonstrate the roles that the rib cage and muscles play in the action of breathing. A balloon inside the bell jar will inflate and deflate as the rubber sheeting on the bottom is pulled down and released.

The Immune System. Students can use a simple simulation to study contagious diseases and the body's immune system. Fill a numbered cup with water for all but one student in the class. Fill the remaining cup halfway with water and the rest of the way with household ammonia. Give each student a new cup and ask them to take half the liquid from the matching numbered cup.

Students interact with peers by answering questions such as "Who would you like to have lunch with?" Then students go to that person and exchange some of the liquid from each other's cup. After about 12 questions, students add a drop of phenolphthalein to their cup. Many liquids will turn pink because they now contain some ammonia. Were they all "infected" with ammonia from the start? Now they add phenolphthalein or another suitable indicator (such as red cabbage juice) to the original cups to show that only one person was originally infected. That student infected all of the others by social contact. How could disease transmission been avoided? How is the body set up to prevent infections?

Supporting Educational Research: *Benchmarks,* pp. 136 (5C), 137 (5C)
Related Science Standards: 1, 2
Related Workplace Readiness Standards: 3.2, 3.3, 3.5, 3.6, 3.12, 4.2, 5.1, 5.2, 5.9

Indicator 8: Describe and give examples of the major categories of living organisms and of the characteristics shared by organisms.

LEARNING ACTIVITIES: Grades 5-6

Field Trip! Students go on a field trip to a designated location. They collect as many living objects as they possibly can within the time frame of the trip. Collection methods include drawing, photographing, and/or videotaping. Upon returning to the classroom, students arrange their collections into areas labeled *PLANTS*, *ANIMALS*, and *UNKNOWN*. Students describe those items ending up in the *UNKNOWN* section, send information to other students via e-mail or the Internet, and/or ask a local high school biology class for help in identifying these unknowns.

Tree/Leaf Identification. By observing the patterns of veins in different leaves, students can use leaf pictures to identify trees. First, explain to students that because each type of tree produces its own distinctive type of leaf, studying leaves is one way scientists identify trees. Students discuss the three main vein patterns in leaves: *palmate*, *parallel*, and *pinnate*. After returning to the classroom, the students can choose from the following activities:

- Students create leaf rubbings by placing the leaf—vein side up—on a flat surface, covering it with a sheet of paper, and rubbing with the side of a crayon (making sure to hold the paper securely). They then compare their leaves, looking for similarities and differences among the various types of leaves. For help in identifying the types of trees from which the leaves were collected, students may use a tree guidebook or biological key.

- As a measurement activity, the students use graph paper for the rubbings and then measure each leaf's surface area.

- Students compose leaf pictures by arranging leaves under paper, muslin squares, or a T-shirt and then rubbing with a crayon.

Supporting Educational Research: *Benchmarks*, p. 342;
National Science Education Standards, pp. 14-15
Related Science Standards: 1, 2, 5
Related Workplace Readiness Standards: 2.7, 3.7-3.9, 5.6, 5.7

LEARNING ACTIVITIES: Grades 7-8

Classifying. Students categorize lists of plants and animals based on similarities and differences in structure. Concept maps can help students organize animals into vertebrates and invertebrates. Students then investigate major groups of vertebrates: fish, amphibians, reptiles, birds, and mammals. Students categorize common plants by the presence of flowers and the patterns of veins.

Animal and Plant Diversity. Students use a variety of sources to investigate the diversity of life.

- A visit to a pet shop provides living examples of most vertebrate groups.
- Plant diversity becomes apparent at any florist.
- Field trips to a zoo, the beach, or any New Jersey State Park can focus on the variety of life.
- The abundance of nature programs on the New Jersey Network and cable television channels offers an instant view of animal and plant diversity.

Plant and Animal Characteristics. As a class, students collect or list examples of living things that they encounter in their community. They then identify each example as *PLANT, ANIMAL,* or *OTHER*. After constructing a chart that compares the distinguishing characteristics of plants and animals, the students challenge each other's findings and debate the meaning of *plant* and *animal*. The characteristics shared by organisms include nutrition, reproduction, excretion, growth, and irritability. Students discover that some living things are neither plant nor animal.

Supporting Educational Research: *Benchmarks,* p. 341; Learning How to Learn
Related Science Standards: 1, 2
Related Workplace Readiness Standards: 1.3, 3.8, 4.3, 4.10, 5.6, 5.9

Indicator 9: Recognize that complex multicellular organisms are interacting systems of cells, tissues, and organs.

LEARNING ACTIVITIES: Grades 5-6

System Components. Students make four large posters for each corner of the classroom and label them *CELLS, TISSUES, ORGANS,* and *SYSTEMS*.(Depending on the number of students in class, you can leave off *SYSTEMS* if you wish.) Students discuss the definitions of each. Each student takes a card with one of the following items written on it:

- *CELLS*—cardiac muscle, smooth muscle, skeletal muscle, nerve, stratified squamous epithelial, bone, fat, red blood cells, white blood cells
- *TISSUES*—muscle, nerve, epithelial, bone, fat, blood
- *ORGANS*—heart, stomach, brain, lungs, liver, bones, skin, blood vessels
- *SYSTEMS*—nervous, endocrine, reproductive, circulatory, muscular, skeletal, respiratory, digestive, urinary

Make sure that the cards are well scrambled. Ask students to go to the appropriate corner and tape their card on the poster. Students can discuss, ask questions, challenge each other, and assist each other.

Multimedia Investigations. Students incorporate a variety of technologies as they study the hierarchy of organization in living things. Using microscopes, students observe wet mounds of onion cells, cheek cells, *Elodea*, and pond-water organisms they have collected. Through both videodisc and Web browsing, students observe a variety of living things and determine where they fit in the hierarchy.

Supporting Educational Research: *Benchmarks,* p. 342; National Science Education Standards, p. 156
Related Science Standards: 1, 2, 4
Related Workplace Readiness Standards: 2.7, 3.10, 4.5

LEARNING ACTIVITIES: Grades 7-8

Images of the Hierarchy. Using new or used catalogs from biological supply houses, students find and cut out pictures that represent each level of organization. They arrange these pictures to depict the relationship between cells, tissues, and organs. If prepared slides are available, students can compare their observations with the cells, tissues, and organs that they found in the catalogs.

Multimedia Investigations. Students incorporate a variety of technologies as they study the hierarchy of organization in living things. Using microscopes, students observe wet mounts of onion cells, cheek cells, and Elodea. Students draw what they see and write a paragraph that explains the hierarchy of organization in living things. Based on their analysis, students formulate definitions of cell, tissue, organ, and system. To supplement this activity, students use videodiscs to retrieve examples of cells, tissues built of these cells, and organs composed of the specific tissues.

Biosphere Components. As an extension of this hierarchy concept, students start at the atomic level to construct a visual illustrating their understanding of the organization of life. The following organization might be used: atom < molecule < cell < tissue < organ < system < organism < population < community < ecosystem < biosphere.

Supporting Educational Research: *Benchmarks*, p. 342;
National Science Education Standards, p. 156
Related Science Standards: 1, 2, 4
Related Workplace Readiness Standards: 2.7, 3.10, 4.5

Indicator 10: Identify and describe the structure and function of cell parts.

LEARNING ACTIVITY: Grades 5-6

Leaf Model. Although leaves come in a variety of shapes and sizes, all leaves perform the common function of photosynthesis. Students describe the cellular structure of a leaf by creating an edible model of a cross section of a leaf. Using a plastic shoe box as a mold, students disperse various foods in gelatin. Each piece of food represents a part of the leaf. The upper and lower epidermis is represented by green gelatin, and the mesophyll is represented by yellow gelatin. Stomata (banana pieces) and the palisade layer (grapes) are also included. Whipped cream represents the waxy cuticle.

Supporting Educational Research: *Benchmarks*, p. 342;
National Science Education Standards, p. 15
Related Science Standard: 2
Related Workplace Readiness Standard: 3.2

LEARNING ACTIVITIES: Grades 7-8

Analogies. These activities helps students construct their understanding of abstract microscopic structures such as the *nucleus, cell membrane, endoplasmic reticulum, mitochondria, cytoplasm, vacuole,* and *ribosome.*

- Students relate cell structure to familiar objects by comparing the cell to a factory. For example, the mitochondria is the energy generator for the cell factory, while the nucleus is the main computer that controls production. Students build a model of the factory, construct a chart, draw a diagram, and/or write an essay that expands the comparison and demonstrates their understanding.

- Alternatively, students can compare the parts of the cells to the human body. For example, the nucleus is the brain of the cell while the endoplasmic reticulum is the cell's circulatory system.

Time Line. As an extension activity, students construct a time line that traces the development of the cell theory from the first observations by Robert Hooke to our current understanding of cell structure.

Cell Model. Cell recipes are a fun way to investigate cell structure and function. Students can construct cell models using materials from the supermarket. They fill sandwich bags (cell membrane) with unflavored gelatin (cytoplasm). They then add the following ingredients to the "cytoplasm":

- cooked spaghetti (endoplasmic reticulum)
- rice (ribosomes)
- a hard-boiled egg (nucleus)
- celery slices (mitochondria)
- a small, water-filled balloon (vacuole)

After placing the "cell" in the refrigerator overnight to allow the gelatin to set, the students get a real feel for the cells by examining and dissecting their creation.

Supporting Educational Research:
Fulfilling the Promise—Biology Education in the Nation's Schools, pp. 18-19;
"Supermarket Cytology—Reinforcing Cell Concepts with Simple Models," pp. 22-25
Related Science Standards: 2, 3
Related Workplace Readiness Standards: 3.2, 5.2, 5.3

Indicator 11: Explain how organisms are affected by different components of an ecosystem and the flow of energy through it.

LEARNING ACTIVITIES: Grades 5-6

Ecosystem Research. In this research and writing activity, students use their knowledge of geography to locate biomes and ecosystems in different parts of the world. Using newspapers, magazines, and/or the Internet, students gather information about deserts, rain forests, or the tundra. After identifying the specific characteristics of each type of habitat, students attempt to determine the impact of humans on the environment. Students present their findings in the form of written reports, posters, or bulletin-board displays. Students can use the Internet to contact students in another biome to compare ecological features.

Ecosystem Simulations. Groups of students construct classroom terraria that represent a variety of ecosystems. Each group chooses a specific type of terrarium such as a desert, woodland, pond, or bog ecosystem. Plastic soda bottles can be easily adapted for this purpose. To construct a pond terrarium, students fill the bottom of a plastic bottle with aquarium gravel or sand, then add pond water, plants, water insects, guppies, and snails. The students research the kind of food needed by each animal. The students maintain accurate records of their observations as a long-term project. Students share information and investigate the effects of light and/or temperature on each terrarium.

Supporting Educational Research: National Science Education Standards, p. 158
Related Science Standards: 1, 2, 12
Related Workplace Readiness Standards: 2.2, 3.4, 4.2-4.9

LEARNING ACTIVITIES: Grades 7-8

Environmental Factors. Through a variety of indoor and outdoor activities, students can investigate the influence of living and nonliving factors on an ecosystem.

- By observing rye grass growing with bean seeds (indoors), students explore the interaction of populations.
- Using water samples that they bring to class, students determine the pH and/or test for the presence of nitrates.
- To determine how environmental factors influence growth, students design a controlled experiment that investigates the effects of light, temperature, moisture, soil type, and/or pH on the growth of radish seeds.

- Using an aquarium, students attempt to determine the effect of light, temperature, and pH on aquatic organisms.
- While outdoors, students collect and organize data on temperature, humidity, barometric pressure, rainfall, cloud cover, and wind direction. (If weather conditions are unfavorable, these data can be easily collected from the Weather Channel.) If students collect information throughout the school year, they can compute long-term averages and graphically display them.

Population Studies. As a field experience, students use sampling techniques to estimate plant populations. Students can easily compare population densities by using bar graphs.

Energy Flow. Using their population studies and investigations of nonliving factors, students attempt to predict the effects of adverse conditions on the flow of energy from producers to consumers. Students can use an energy pyramid to illustrate the relationship between amount of energy and the trophic levels.

Supporting Educational Research:
Fulfilling the Promise—Biology Education in the Nation's Schools, p. 24;
National Science Education Standards, p. 155.
Related Science Standards: 1, 2, 5, 12
Related Workplace Readiness Standards: 2.2, 3.12, 5.4, 5.11

Indicator 12: Illustrate and explain the life cycles of organisms.

LEARNING ACTIVITIES: Grades 5-6

Mealworm Life Cycle. Students use mealworms to investigate life cycles. Mealworms (beetle larvae) are easily maintained in the classroom and can be used to trace the development of an insect. Students record observations in a notebook or draw diagrams to show changes that occur. Students discover that a fertilized egg develops into a larva, which later changes into an adult form. Students compare the life cycle of the mealworm to that of other organisms.

Bird Life Cycle. Students construct their knowledge of life cycles by investigating familiar examples. The life cycle of birds provides insight into the stages of life. Students research the structure of a bird egg and trace the development of the embryo through its hatching. They recognize that young birds become adults and that adult birds take care of their young. Students diagram stages of chick embryonic development. They then compare the life cycle of birds to that of other familiar species like fish, frogs, and dogs.

Supporting Educational Research: National Science Education Standards, p. 157.
Related Science Standard: 2
Related Workplace Readiness Standards: 3.9, 4.2

LEARNING ACTIVITIES: Grades 7-8

Human Life Cycle. All of the events that occur between the beginning of one generation and the beginning of the next are part of the life cycle of an organism. Because the life cycles of plants and animals are continuous, students diagram these events as a circle. The human life cycle is an effective example of this biological concept. By comparing the life cycles of other living things to the life cycle of humans, students can gain an understanding of the variety of reproductive patterns.

Frog Life Cycle. To investigate the amphibian life cycle, students trace the development of a frog from egg to tadpole to adult. Eggs of *Rana pipiens* or *Xenopus laevis* are effective for this activity. Students keep a log of their observations and diagram the phases of development. If both types of eggs are available, students can compare the development and determine if development time varies with the species.

Butterfly Life Cycle. Raising butterflies is an exciting and inexpensive way to explore insect life cycles. The painted lady butterfly *(Vanessa cardui)* begins its life cycle as a small, pale-green egg. After several molts, the larva begins to pupate. The adult emerges after 7 to 10 days. For comparative purposes, students can collect crickets and maintain them in the classroom. The cricket *(Acheta domesticus)* demonstrates the nymph stage of the insect life cycle.

Plant Life Cycles. Students explore plant life cycles by germinating seeds. Students can plant corn and bean seeds in order to trace plant development. Alternatively, they can use Wisconsin Fast Plants™ *(Brassica rapa)*, which have a life cycle of 35 days. Shortly after students plant these seeds, seedlings emerge and develop. Students pollinate flowers and observe the formation of pods. Students compare the life cycles by drawing diagrams that include each stage of development.

Career Exploration. As an extension activity, students explore careers related to entomology and horticulture.

Supporting Educational Research: National Science Education Standards, p. 157.
Related Science Standard: 2
Related Workplace Readiness Standard: 1.3

Indicator 13: Identify and describe organisms that possess characteristics of living and nonliving things.

LEARNING ACTIVITIES: Grades 9-12

Respiration and Growth Investigations. This activity focuses on two life processes: *respiration* and *growth*.

- Students use bromothymol blue to detect the presence of carbon dioxide (a respiration by-product).
- They use germination and/or movement as growth indicators.

Students test these processes in "unknown" materials such as unlabeled radish seeds, bean seeds, lentils, packaged yeast, brine shrimp eggs, sawdust, sugar, salt, sand, and vermiculite. Students conduct the investigation in three segments:

- Using a microscope and hand lens, students observe the specimens and record their observations.
- They then test each material for carbon dioxide production.
- To determine growth characteristics, students place each unknown in a petri dish with a moist paper towel. They record their observations for at least four days.

Pond-Water Life. As an extension activity, students use microscopes to examine pond water. They try to distinguish between living and nonliving things in the sample. Students list the characteristics that are features of living systems. Point out that the characteristics universal to life are not always easy to observe. For example, a distinguishing feature of all life is the presence of cells or DNA.

Supporting Educational Research: *Benchmarks*, p. 341
Related Science Standard: 1
Related Workplace Readiness Standards: 2.2, 2.7, 3.9, 5.1, 5.4, 5.6

Viruses and Technology. Students examine electron micrographs of viruses. The students identify the characteristics of viruses that might indicate that they are living or nonliving. Using databases, students explore the impact of technology (e.g., electron microscopy or electrophoresis).

Viruses and Health. As a research and writing activity, students use databases to describe viruses that have a significant effect on world health. These viruses include Ebola and HIV/AIDS. Students describe modes of transmission and construct a global map depicting population distributions of infected individuals. As an extension of this learning experience, students view videos such as *The Band Played On or Common Threads*. These videos focus on the spread and identification of the origin of viruses. Students can obtain research information and epidemiological statistics from the Centers for Disease Control and Prevention (CDC) through the Internet.

Supporting Educational Research: *Benchmarks,* p. 341
Related Science Standards: 2, 4, 5
Related Workplace Readiness Standards: 2.7, 3.12

Indicator 14: Identify and explain the structure and function.

LEARNING ACTIVITIES: Grades 9-12

Modeling Organic Nutrients. Students review the basic organic structures of carbohydrates, fats, and protein. In a cooperative learning experience, students design and construct models of three organic molecules that are found in living things: a simple sugar, a fat, and an amino acid. Students construct the molecular models from everyday materials such as paper clips, pipe cleaners, toothpicks, Styrofoam™ balls, colored tissue, aluminum foil, gumdrops, beads, seeds, or colored macaroni.

Testing for Organic Nutrients. For each type of organic nutrient, students describe its use in the cell, list examples, and explain its function. They then perform standard tests for the presence of each type of organic nutrient.

Testing Enzyme Activity. To demonstrate the variables that affect enzyme activity and substrate specificity, students run enzyme tests using potato or fresh calf liver. (Both contain the enzyme peroxidase.) Students determine the degree of enzyme activity by measuring the height of a foam column that is produced when the substrate (peroxide) is added. Students vary the pH, temperature, and amount of substrate to determine the optimum conditions for enzyme function. They then graphically represent their results. Students can use electronic probes connected to computers or calculators to make these measurements.

Supporting Educational Research: *Benchmarks,* p. 337;
Fulfilling the Promise—Biology Education in the Nation's Schools, p. 22
Related Science Standards: 2, 4, 5
Related Workplace Readiness Standards: 3.2, 4.2-4.9, 5.7

Indicator 15: Explain how plants convert light energy to chemical energy.

LEARNING ACTIVITIES: Grades 9-12

Investigating Photosynthesis. Students discover many of the basic facts of photosynthesis through laboratory experiences.

- Students determine if light is necessary for the production of starch (glucose). They loosely wrap some of the leaves of a *Geranium*, *Coleus*, or *bean plant* in foil and place the plant in bright light for several days. They pick the covered leaves and boil them first in water and then in alcohol. Next, they perform iodine tests for starch on the leaves. As a control, they conduct the same procedure on leaves that were not covered.

- Students investigate the effects of varying intensities of light on the amount of oxygen produced. They place aquatic *Elodea* plants in test tubes full of aquarium water and expose the test tubes to lamps placed at varying distances (5 cm outward). They cut the stems of the *Elodea* on a diagonal and place them in the test tubes upside down. Oxygen bubbles form on the cut end of the stems at a rate related to the distance from the lamp.

- Students determine if carbon dioxide is taken up by plants when the plants are exposed to light. First, students place a few drops of bromothymol blue (a carbon dioxide indicator) in a test tube partially filled with water. They exhale through a straw into the test tube until the color turns yellow. They then place an *Elodea* plant in the water in the test tube and expose it to light. (Bromothymol blue is not harmful to *Elodea*.) As the plant absorbs carbon dioxide, the yellow color changes back to blue.

- For extension, students design and carry out their own experiments to investigate how factors such as temperature or the concentration of carbon dioxide affect the rate of photosynthesis.

- The above experiments can be supported and extended through the use of computer lab interface devices or calculator probes to measure pH (carbon dioxide dissolved in water), light intensity, and temperature.

Supporting Educational Research: *Benchmarks,* p. 113
Related Science Standards: 2, 4
Related Workplace Readiness Standards: 2.7, 3.8, 3.12, 5.5, 5.8, 5.9

Indicator 16: Describe how plants produce substances high in energy content that become the primary source of energy for animal life.

LEARNING ACTIVITIES: Grades 9-12

Illustrating Plant/Animal Interdependence. The following activities illustrate the interdependence between plants and animals.

- Students set up, maintain, and observe a classroom aquarium or terrarium as an ongoing, small-scale example of the interdependence of living things and of the relationship between photosynthesis and respiration.

- As a challenge, students design and construct their own sealed terrarium, in which the only thing entering the system from the outside is sunlight.

Students use print and/or Internet resources to research the Biosphere project in Oracle, Arizona, to determine how it was set up, what problems were encountered, and how those problems are being addressed.

Supporting Educational Research: *Benchmarks*, pp. 118-21
Related Science Standards: 1, 2
Related Workplace Readiness Standards: 2.6, 3.7, 4.2-4.9

Investigating the Photosynthesis/Respiration Connection. The following activities enable students to investigate the relationship between photosynthesis and respiration.

- To illustrate the interdependence of plant and animal life, students take a small sample of water from a healthy classroom aquarium and test it with a few drops of bromothymol blue for the presence of carbon dioxide (carbonic acid). They fill a beaker with water from the aquarium and place a goldfish in the beaker. Students periodically remove a few milliliters of water from the beaker and retest for carbon dioxide. When the water in the beaker tests positively for carbon dioxide, students return the goldfish to the aquarium. They then place a few aquatic plants such as *Elodea* into the water in the beaker, add a few drops of bromothymol blue, and place the beaker in bright light for a day or two.

- As an extension, students use print and/or Internet resources to investigate the historical contributions of the British chemist, Joseph Priestley.

Supporting Educational Research: *Benchmarks*, pp. 82, 118-21
Related Science Standard: 3
Related Workplace Readiness Standards: 2.6, 3.9, 5.4

Indicator 17: Compare and contrast the life cycles of living things as they interact with ecosystems.

LEARNING ACTIVITIES: Grades 9-12

Effect of Environmental Factors on Germinating Seeds. In the following activities, students investigate the response of the roots and stems of germinating corn or bean seeds to such environmental factors as gravity, light, and water.

- To investigate the response of germinating roots and stems to gravity, students place four soaked corn or bean seeds on barely moist paper towels that are pressed into a petri dish. The seeds should be at the 3 o'clock, 6 o'clock, 9 o'clock, and 12 o'clock positions. The students then stand the petri dish on edge in a fixed position and check daily for the direction of growth of the emerging root and shoot.

- As an extension, students work in cooperative lab groups to design their own experiments testing the responses of germinating seeds to the direction of a light source or a water source. Students focus not only on the design of their experiments but also on writing detailed procedures. (They will swap experimental designs and procedures with another group before carrying out the experiment.)

Supporting Educational Research: *Benchmarks*, pp. 118-21
Related Science Standard: 2
Related Workplace Readiness Standards: 3.6-3.12, 4.2-4.9

Fallen Leaves and Invertebrate Populations. The following activities enable students to study the interaction of living things in an ecosystem.

- Using ordinary plastic net bags (e.g., onion, orange, or grapefruit) filled with leaves, students investigate how the life cycle of a deciduous tree impacts the life cycles of invertebrates. Students fill the net bags with 50 leaves of varied types and dryness. In mid-October, the bags are secured to rocks in a stream bed or tied to trees and placed where natural leaf packs form. After three weeks, students return to recover their net bags. (Bags that were in stream water should be placed in containers filled with stream water.) Students note the diversity of life forms on the leaves.

- As an extension, students explore the work of limnologists, EPA officials in the field, and insect control agencies.

Supporting Educational Research: *Benchmarks*, p. 121;
Fulfilling the Promise, p. 21
Related Science Standards: 2, 12
Related Workplace Readiness Standards: 1, 3.9, 4.2-4.10

SCIENCE STANDARD 7

All students will investigate the diversity of life.

INTRODUCTION

This standard expands students' biological understanding of life by focusing on diversity, evolution, and heredity. The concept of diversity provides a foundation on which students build an understanding of evolution and genetics. To achieve this standard, students explain the natural variation that exists in all living things.

Evolution is the central theme of biological science. The mechanism of evolution is natural selection. The raw materials for this mechanism are mutations, and these mutations can be passed from one generation to another by reproduction. Reproductive success ensures adaptation to a changing environment. Students should be able to explain the genetic basis for evolution.

To relate evolution, reproduction, and adaptation, this standard explores principles of heredity. The inheritance of traits is explained through the basic laws of genetics, and DNA is presented as the molecule of heredity. Expanding on Standard 5.6 ("Science Standard 6"), students are able to explain why the presence of DNA is a fundamental feature of living things. The role of DNA in natural selection is explored.

DEVELOPMENTAL OVERVIEW

In grades K-2, children observe the variety of life. They begin to recognize relationships by identifying similarities and differences of familiar things. In grades 3-4, children develop grouping schemes for seeds, leaves, and seashells. In grades 5-6, students use binary keys for classification and develop their own grouping systems. Diversity is investigated in grades 7-8 by examining animal skeletons and types of flowers. At the high school level, diversity is explained by genetic variation.

In the primary grades (K-4), simple observations introduce the concept of variation within a species, a central theme of evolution. In grades 5-6, students investigate how changing environmental conditions result in the evolution of a species. The peppered moth is used an example. Students in grades 7-8 use the fossil record to trace the evolution of the horse, and natural selection is explained in terms of survival of the fittest. In grades 9-12, students evaluate evidence for evolution by investigating the finches of the Galapagos and the amino acid sequences of hemoglobin molecules.

Genetics is introduced in the primary grades by recognizing that offspring resemble their parents. Children in grades 5-6 distinguish between acquired and inherited characteristics, and the role of genes in inheritance is explored. In grades 7-8, students use genetics to explain patterns of human inheritance, and they relate genetics to evolution. At the high school level, students construct their understanding of the molecular basis of heredity by building models of DNA. The processes of duplication, transcription, and translation are related to biotechnology.

Descriptive Statement: The study of science must include the diversity, complexity, and interdependence of life on Earth. Students should know how organisms evolve, reproduce, and adapt to their environments. *Science Standards 6 and 7* serve to define the fundamental understandings of the life sciences.

CUMULATIVE PROGRESS INDICATORS

By the end of Grade 4, students

1. Recognize the diversity of plants and animals on Earth.
2. Develop a simple classification scheme for grouping organisms.
3. Recognize that individuals vary within every species.
4. Identify and describe external features of plants and animals that help them survive in varied habitats.

Building upon knowledge and skills gained in the preceding grades,
by the end of Grade 8, students

5. Illustrate how the sorting and recombining of genetic material results in the potential for variation among offspring.
6. Compare and contrast acquired and inherited characteristics.
7. Classify organisms by their internal and external characteristics.
8. Discuss how changing environmental conditions can result in evolution of a species.
9. Recognize that individual organisms with certain traits are more likely to survive and have offspring.
10. Describe how information is encoded in genetic material.

Building upon knowledge and skills gained in the preceding grades,
by the end of Grade 12, students

11. Explain how DNA can be altered by natural or artificial means to produce permanent changes in a species.

12. Explain that through evolution the Earth's present species developed from earlier distinctly different species.

13. Explain how the theory of natural selection accounts for an increase in the proportion of individuals with advantageous characteristics within a species.

LIST OF LEARNING ACTIVITIES FOR STANDARD 7

GRADES K-4

Indicator 1:

GRADES K-2
Picture Safari

GRADES 3-4
Mini Habitats

Indicator 2:

GRADES K-2
Mixed Seeds and a Shoe Pile

GRADES 3-4
Classifying Seashells and Other Things

Indicator 3:

GRADES K-2
Observing Variation within a Species

GRADES 3-4
Peanuts and Leaves

Indicator 4:

GRADES K-2
Searching for Food

GRADES 3-4
Designing Adaptations

GRADES 5-8

Indicator 5:

GRADES 5-6
Inheritance of Genetic Traits

GRADES 7-8
Documenting Variation within a Species

Indicator 6:

GRADES 5-6
Acquired or Inherited?

GRADES 7-8
Studying Inherited Traits

Indicator 7:

GRADES 5-6
Classifying Characteristics

GRADES 7-8
A Key for Grouping Organisms

Indicator 8:

GRADES 5-6
Moth Adaptation

GRADES 7-8
Evolution: Past and Present

Indicator 9:

GRADES 5-6
Bird Adaptations and Habitats

GRADES 7-8
Natural Selection

GRADES 9-12

Indicator 10:

DNA: Its Function

Indicator 12:

Evolution: Historic Case Studies

Indicator 11:

Genetic Recombination

Indicator 13:

Natural Selection Analogue

Indicator 1: Recognize the diversity of plants and animals on Earth.

LEARNING ACTIVITY: Grades K-2

Picture Safari. Students create "picture safaris" by cutting out pictures of plants and animals from various habitats. After this introduction to the diversity that exists in nature, they role-play the different feeding levels of organisms. They can create masks to identify the kind of animal or plant they are imitating. By talking about where they live and how they get food, students easily recognize the differences between them.

Supporting Educational Research: *Benchmarks*, pp. 102, 116
Related Science Standards: 6, 12
Related Workplace Readiness Standards: 3.2, 4.7, 5.6, 5.7

LEARNING ACTIVITY: Grades 3-4

Mini Habitats. Students create simple quadrants of living things by pulling a hanger into a diamond shape and laying it on the ground. Within these quadrants, they look for different types of animal and plant species. Students can set up quadrants in different habitats and compare the results.

As a mathematical extension of this activity, students can use population statistics.

Supporting Educational Research: *Benchmarks*, p. 103 (5A)
Related Science Standards: 5, 6, 12
Related Workplace Readiness Standards: 3.7, 3.8

Indicator 2: Develop a simple classification scheme for grouping organisms.

LEARNING ACTIVITY: Grades K-2

Mixed Seeds and a Shoe Pile. A bag of mixed seeds—including different kinds of beans, peas, and nuts—is a simple way to introduce the concept of grouping like things. Students can easily observe differences in color, shape, and texture.

Creating a "shoe pile" from students' shoes also helps improve observation of detail for classification.

Supporting Educational Research: *Benchmarks,* p. 116
Related Science Standards: 2, 6, 12
Related Workplace Readiness Standards: 3.7, 3.8, 3.9

LEARNING ACTIVITY: Grades 3-4

Classifying Seashells and Other Things. Seashells come in a wide variety of colors, shapes, and sizes. To practice using a simple classification technique, students sort shells into categories.

Using cutout shoe boxes, students make panoramas representing different types of habitats, such as a pond, an ocean, a desert, or a forest. Give students an assortment of plant and animal pictures. They can then determine which organisms belong in which habitat.

Supporting Educational Research: *Benchmarks,* p. 103
Related Science Standards: 2, 6, 12
Related Workplace Readiness Standards: 3.2, 3.8, 3.12

Indicator 3: Recognize that individuals vary within every species.

LEARNING ACTIVITY: Grades K-2

Observing Variation within a Species. Last year's calendars with pictures of puppies, kittens, or horses on them help children recognize differences in organisms of the same species. Children can describe what makes their particular kitten or puppy different from the rest.

Potatoes can be used to show differences within a plant species. Each child "adopts" a potato and carefully examines it. Several children place their potato in a box at the same time, and then see if they each can recognize which potato is theirs.

Supporting Educational Research: *Benchmarks,* p. 102 (5A)
Related Science Standard: 6
Related Workplace Readiness Standards: 3.7, 3.9

LEARNING ACTIVITY: Grades 3-4

Peanuts and Leaves. A small collection of 25 unshelled peanuts or 25 leaves from the same tree help students quantitatively determine how individuals within a species vary. By weighing the peanuts or measuring the length of each leaf, students see that they are not all the same size. Tallying those with common weights or lengths, students can create bar graphs to illustrate similarities and differences.

Supporting Educational Research: *Benchmarks,* p. 103 (5A)
Related Science Standards: 2, 6
Related Workplace Readiness Standards: 3.3, 3.9, 3.12

Indicator 4: Identify and describe the external features of plants and animals that help them survive in varied habitats.

LEARNING ACTIVITY: Grades K-2

Searching for Food. In this activity, students explore adaptations for survival. First, each student selects a small, roped-off area of grass in which to drop prey. Then they toss candies of different colors (including green and red) randomly into the plot. During a brief "hunting season," students search their respective areas for as many candies as they can find. Afterward, discuss with the class what makes some candies harder to find than others. Ask the students which were the easiest to find.

Hang posters of several different habitats on the walls around the classroom and give students pictures of different plants and animals. They place the pictures on the correct posters and explain why that habitat is where the organism would live.

Supporting Educational Research: *Benchmarks,* p. 102
Related Science Standard: 12
Related Workplace Readiness Standards: 3.2, 3.6, 4.2

LEARNING ACTIVITY: Grades 3-4

Designing Adaptations. Seeds are dispersed in a variety of ways. Each student selects a method of dispersal and designs a seed that will be successfully dispersed by that method. They test their designs using a small fan, a pan of water, or a piece of fuzzy material.

As another challenge to their creativity, give students a description of an unknown planet, and ask them to design a creature that would be able to survive on that planet. Encourage students to consider those creatures that live underground, in water, and on land.

Supporting Educational Research: *Benchmarks,* p. 103
Related Science Standards: 2, 6, 12
Related Workplace Readiness Standards: 3.6, 3.12, 3.16

Indicator 5: Illustrate how the sorting and recombining of genetic materials results in the potential for variation among offspring.

LEARNING ACTIVITY: Grades 5-6

Inheritance of Genetic Traits. This exercise introduces students to the concept of dominance in the transmission of genetic traits. In prelab discussion, students learn that in sexually reproducing organisms half of the genes are inherited from each parent and that genes carry the genetic code. They review the contributions of Gregor Mendel and his famous pea plants.

Working individually or in small groups, students begin with 24 blue opaque disks, 24 transparent disks, and four paper bags. They label each of the paper bags as "Pure Blue Parent," "Pure Transparent Parent," "First Generation," or "Second Generation."

The students place two blue disks together, one on top of the other, and hold them up to the light. They observe and record the color of the two disks while held together, and then place these disks into the bag labeled "Pure Blue Parent." The students repeat this procedure until all of the blue disks are in that bag. They carry out the same procedure for the transparent disks until they all end up in a bag labeled "Pure Transparent Parent."

Next, students remove one disk from the "Pure Blue Parent" bag and one disk from the "Pure Transparent Parent" bag. They place these two disks together and hold them up to the light. They observe and record the resultant color, and then place these two disks in the bag labeled "First Generation." The students continue removing one disk from each "parent" bag, holding them together under the light, recording their observations, and then placing them in the "First Generation" bag.

When the students have paired (and relocated) all of the disks in this way, they close the "First Generation" bag and shake it. Blindly and randomly, the students pick two disks from the bag, hold them together under the light, and observe the resultant color. They record the color when thus combined, as well as the color of each of the two disks, and place the two disks into the bag labeled "Second Generation." The students continue until they have taken out all of the disks from the "First Generation" bag. If the data sheets are properly constructed, the results should lead to an interesting discussion of dominant and recessive genes, and perhaps also probability.

Supporting Educational Research: *Benchmarks*, p. 341;
Fulfilling the Promise, pp. 18-20
Related Science Standards: 2, 5
Related Workplace Readiness Standards: 2.1, 3.12

LEARNING ACTIVITY: Grades 7-8

Documenting Variation within a Species. Students investigate variation within a species by identifying a characteristic they can easily measure. Working in groups, they study individual variations in size among plant populations and interpret the data by statistical methods.

First, they obtain a sample of about 50 dried bean seeds or unshelled peanuts. They measure the length of each seed to the nearest millimeter. Using the length data, students construct a frequency distribution table and a bar graph (with intervals on the horizontal axis and the frequency on the vertical axis). They calculate the mean, median, and mode for their data. Students can pool their group data into class data and construct a more comprehensive bar graph. They can use computer graphing to compare and present data. For additional experience, student groups might swap samples with each other and remeasure the seeds.

This time of development for middle school students lends itself to human biology. Variations in the students' height or distance between the eyes might be considered as an extension activity.

Supporting Educational Research:
National Science Education Standards, p. 156;
Fulfilling the Promise, p. 19
Related Science Standards: 2, 5
Related Workplace Readiness Standards: 2.7, 3.7, 3.9

Indicator 6: Compare and contrast acquired and inherited characteristics.

LEARNING ACTIVITY: Grades 5-6

Acquired or Inherited? The distinction between acquired and inherited characteristics is central to evolution and genetics. Explain the distinction to the students and give examples of each. A possible example is shaving one's head vs. male pattern baldness. Both lead to bare heads, but the first is acquired and the second is inherited.

Each cooperative learning group comes up with as many acquired and inherited characteristics found in humans as possible. After compiling these two lists of characteristics, the groups come together and compare lists. Discussion can bring out interesting features to help students compare and contrast the two types of characteristics.

(These lists might be interesting to keep for 10 to 20 years. Science changes and so will what we know about genetics today.)

Supporting Educational Research: *Benchmarks,* p. 341;
Fulfilling the Promise, pp. 18-20
Related Science Standard: 6
Related Workplace Readiness Standards: 3.8, 3.14, 4.2

LEARNING ACTIVITY: Grades 7-8

Studying Inherited Traits. Some students of all ages believe that certain environmentally produced characteristics can be inherited over several generations. To address this misconception, students need to distinguish between traits that are inherited and those that are acquired. Acquired characteristics in humans are easily identified. For example, hair color can be changed with the use of dyes; the appearance of teeth can be altered with braces. Other examples of acquired characteristics can be found in domesticated animals. The tails of some dogs are removed; pets are trained to eat food that would not be a natural source of nourishment.

To investigate examples of inherited characteristics, students study

- foot and beak adaptations of birds
- neck length in giraffes
- flower color, leaf arrangement, or seed shape in plants
- hair color, eye color, tongue rolling, shape of earlobes, color blindness, and dimples in humans (e.g., themselves)

As an enrichment activity, students investigate the development of twins. They research studies of twins that are separated at birth and then draw conclusions about acquired vs. inherited characteristics.

Supporting Educational Research: *Benchmarks*, p. 341;
Fulfilling the Promise, p. 19
Related Science Standards: 2, 6, 12
Related Workplace Readiness Standards: 3.7, 3.12, 3.14

Indicator 7: Classify organisms by their internal and external characteristics.

LEARNING ACTIVITY: Grades 5-6

Classifying Characteristics. Students practice classifying species by using a binary (dichotomous) key. The entire class divides into two categories based on external characteristics, for example, male vs. female, blonde hair vs. other, brown eyes vs. other. Within each category, students create more groups with distinct characteristics and divide until every student is standing alone. Next, each student traces back the characteristics. For example, Bob is wearing a belt, belongs to a group wearing blue jeans, belongs to a group with brown hair, belongs to a group with brown eyes, and is a male.

Careful consideration should be given to the selection of categories so that students are not offended or embarrassed during this activity.

As an extension activity, students examine or design keys for trees, rocks, shells, etc.

Supporting Educational Research: *Benchmarks*, p. 340
Related Science Standard: 2
Related Workplace Readiness Standards: 3.9, 4.2

LEARNING ACTIVITY: Grades 7-8

A Key for Grouping Organisms. Similarities and differences in structure are the basis for classifying living things. The investigation of animal skeletons is a fun way to continue the development of classification schemes. Students first generate a list of animals. From this list, they identify animals with an internal skeleton and those with an external skeleton. This characteristic leads to a discussion of vertebrates and invertebrates. Afterwards, students examine and compare internal characteristics by dissecting specimens, studying models, or using computer simulations.

Students collect plants from the school grounds and categorize them by type of venation, presence of flowers, or arrangement of leaves.

To further refine their skills of observation and classification, students can use dichotomous keys to classify insects, fish, birds, or trees.

Supporting Educational Research: *Benchmarks*, p. 340
Related Science Standard: 2
Related Workplace Readiness Standards: 3.7, 3.9, 4.2

Indicator 8: Discuss how changing environmental conditions can result in evolution of a species.

LEARNING ACTIVITY: Grades 5-6

Moth Adaptation. Students graph and interpret changes in color among the peppered moth population near Manchester, England, during the Industrial Revolution. These variations show evolutionary adaptation to the environment.

Before 1845, the light-colored variety was common, and darker individuals were rare. During the 10-year study, the numbers changed considerably. Apparently, the moths were active at night and rested on tree trunks during the day, where they were eaten by birds. The trees had light-gray trunks at the beginning of the study, but the trunks got darker during the period as a result of factory pollution and coal burning.

Moth population data can be easily found in most high school biology texts. Students graph and interpret the data, attempting to answer the question, "What appears to be the connection?"

Supporting Educational Research: *Benchmarks,* p. 34
Related Science Standards: 1, 2, 5
Related Workplace Readiness Standards: 2.4, 2.6, 3.2

LEARNING ACTIVITY: Grades 7-8

Evolution: Past and Present. Evidence that modern species evolved from ancient organisms can be found in the fossil records. Using reference materials, diagrams, charts, and illustrations, students work in cooperative groups to discuss how the horse changed over time. Each group prepares a chart illustrating the changes in size, leg anatomy, and tooth anatomy that occurred due to change of climate, terrain, and diet. Students present their report and illustrations to the class for evaluation. Other organisms that students can study in a similar manner are the giraffe, the elephant, snails, and the New Jersey pitch pine.

As an extension of this activity and as a way to show the ongoing nature of evolution, students use various telecommunication techniques to connect with environmental classes and other research agencies throughout the nation. They use the data obtained to analyze the effect of environmental changes on living organisms. They learn about changes such as the following:

- During ecological pond studies, students in a midwestern state found multi-appendaged frogs in several ponds in their community.
- In Florida, cockroaches became resistant to a poisonous bait that previously had killed them.

By sharing research information in this way, students can use the data to discuss the impact of environmental changes on organisms. Schools can develop data exchanges in written communications.

Supporting Educational Research: Fulfilling the Promise, pp. 23-24;
National Science Education Standards, pp. 156-158
Related Science Standards: 1, 2, 12
Related Workplace Readiness Standards: 3.3, 3.13

Indicator 9: Recognize that individual organisms with certain traits are more likely to survive and have offspring.

LEARNING ACTIVITY: Grades 5-6

Bird Adaptations and Habitats. Adaptations are the special inherited characteristics of an organism that make it suited to survive in a particular habitat. An adaptation may be structural (e.g., crab claws, fish fins), chemical (e.g., an enzyme), or behavioral. Beak and foot adaptations in birds are structural adaptations that are relatively easy for students to see and study.

Students begin their study of bird adaptations with appropriate reference books and pictures of various types of bird beaks and feet. They examine charts matching beak types with the functions (usually food-related) that they enable the bird to perform. Then they look at pictures of birds' heads and determine what type of beak each has and the type of habitat for which each bird is suited. Is that, in fact, where these birds are found? Students can repeat this process, "adapting" it to birds' foot types.

For a hands-on extension activity, students try food gathering as if they were a bird. They use the assigned tools to gather their "food" (see list below).

- *Fish eater*—large forceps; plastic fish floating in a large bowl of water
- *Meat eater*—staple remover; stuffed mice
- *Insect eater*—chopsticks; gummy bears
- *Seed eater*—paper plate of popcorn (students' hands behind their backs)
- *Fruit eater*—melon-ball scooper; grapes
- *Grain eater*—toothpicks taped to fingertips; uncooked rice sprinkled into crevices of bark

Supporting Educational Research: *Benchmarks,* p. 343;
National Science Education Standards, pp. 18-20
Related Science Standard: 12
Related Workplace Readiness Standards: 3.9, 3.12

LEARNING ACTIVITY: Grades 7-8

Natural Selection. Students construct their understanding of natural selection in relation to the survival of the fittest (the strong survive and the weak die). To apply this principle of natural selection, students examine pictures of plants and animals. They describe unique features that help organisms to survive. Examples might include the following:

- the white fur of a polar bear
- the prehensile tail of a monkey
- the spine of a cactus

A field trip to a zoo, the New Jersey State Aquarium, or Liberty Science Center is an exciting way to illustrate this concept.

As an alternative activity, students "design a creature." Using clay models, drawings, cutouts, or computer graphics, the students design an imaginary plant or animal. In a written report or oral presentation, students explain the survival feature of their special creature. To extend this activity, students predict the results of a theoretical pairing of animals.

Supporting Educational Research: *Benchmarks,* pp. 343-344;
National Science Education Standards, p. 156
Related Science Standard: 2
Related Workplace Readiness Standards: 2.9, 3.7, 4.2

Indicator 10: Describe how information is coded in genetic material.

LEARNING ACTIVITY: Grades 9-12

DNA: Its Function. To describe the function of DNA, students use templates or cutouts of the parts of the DNA molecule. Manipulating these models, they investigate duplication, transcription, and translation.

As an extension activity, students conduct a DNA fingerprint simulation. A specific gene pattern sequence is simulated on graph paper. Genes are numbered 1 to 7, with repeats occurring to produce a total number of 29 genes. Various combinations are produced. Students "cut" their DNA between gene 4 and gene 5 by using a "restriction enzyme." This cut produces fragments of varying sizes. The simulated gel consists of a strip of graph paper numbered 1 to 25 (starting with the #1 at the bottom). A band is colored at the corresponding points of the genes. Using an unknown sequence, students can identify DNA fragments of a criminal and victim.

Other extension activities might include the following:

- exploring the use of DNA in forensic science
- finding career options in criminal science
- searching databases for protocols for DNA extraction

Supporting Educational Research: *Benchmarks*, p. 341 (5B);
Fulfilling the Promise, p. 22
Related Science Standards: 1, 3
Related Workplace Readiness Standards: 1.3, 2.5, 2.7, 3.12

Indicator 11: Explain that DNA can be altered by natural or artificial means to produce changes in a species.

LEARNING ACTIVITY: Grades 9-12

Genetic Recombination. To demonstrate that traits can be acquired by genetic recombination, students culture two different strains of E. coli on an agar plate. One strain is ampicillin resistant; the other is streptomycin resistant. When the two cultures are grown together, conjugation occurs and a new strain forms that is resistant to both antibiotics. Students test transformations by growing colonies on plates that contain both the streptomycin and the ampicillin.

As an extension activity, students use databases to identify industrial applications of bacterial transformations such as

- the production of vaccines and synthetic drugs
- the improvement of crop resistance

Supporting Educational Research: *Benchmarks*, p. 343;
Fulfilling the Promise, p.22
Related Science Standards: 1, 3, 4
Related Workplace Readiness Standards: 3.12, 5.4, 5.7

Indicator 12: *Explain that through evolution, the Earth's present species developed from earlier and distinctly different species.*

LEARNING ACTIVITY: Grades 9-12

Evolution: Historic Case Studies. In cooperative groups, students investigate some of the classic case histories of evolution including the following:

- the peppered moths in Manchester, England
- the changes in average horse height and the size of bones in their feet over the past 60 million years
- the differences in the amino acid sequences in the hemoglobin molecules of humans, fruit flies, chimps, horses, and other organisms
- the variations in the beaks of finches in the Galapagos Islands

Students conduct their research using science software and the Internet. They present a summary of their findings in verbal, graphic, and electronic form. Afterwards, the class discusses the similarities and differences in these four cases.

About 25 years ago, the oldest intact human skeleton was discovered in Africa by Drs. Louis and Mary Leakey. As an interdisciplinary extension activity, students write a poem as the fossil "Lucy," addressing her ancestors.

Supporting Educational Research: *Benchmarks*, p. 343
Related Science Standard: 1
Related Workplace Readiness Standards: 2.6, 3.8, 4.2

Indicator 13: Explain how the theory of natural selection accounts for an increase in the proportion of individuals with advantageous characteristics within a species.

LEARNING ACTIVITY: Grades 9-12

Natural Selection Analogue. Students use a simulation to demonstrate coloration as a result of natural selection. This activity requires only a newspaper, black and white construction paper, a large box, and scissors. Students cut the newspaper to the same size as the construction paper, then fold it into 64 rectangles that are to be cut out. In the same fashion, fold the black and white construction paper and cut out the 64 rectangles. The three types of rectangles simulate three “organisms” within the “environment,” which is a large piece of newspaper lining the bottom of the large box. Randomly, one of the students drops the organisms into the environment. Other students act as “predators” on the animals in the box. Each predator, at a glance, reaches into the box and quickly identifies and removes an organism. After each predator removes an organism, the number of each remaining organism is tallied. Based on this, students make predictions about future populations.

As a supplement to this activity, students research other populations that have been affected by natural selection.

Supporting Educational Research: *Benchmarks,* p. 343
Related Science Standard: 12
Related Workplace Readiness Standards: 2.4, 3.2, 3.3, 3.12, 3.14

SCIENCE STANDARD 8

All students will gain an understanding of the structure and behavior of matter.

INTRODUCTION

This standard, together with *Science Standard 9,* defines the fundamental understandings of the physical sciences. Specifically, the focus of *Science Standard 8* is on matter—its properties, its states, and its structure. Because matter is readily available (as solid, liquid, or gas), students can begin exploring its nature at the earliest ages, making observations and conducting hands-on investigations. Students gain an understanding of basic chemistry through experiences that allow students to sort and classify matter and to study the behavior of matter under changing conditions. Eventually their understanding of elements, mixtures, compounds, and reactions can be seen in the context of atomic structure and the periodic table of elements.

DEVELOPMENTAL OVERVIEW

How does a young child begin to make sense of all the "stuff" that makes up the world in which we live? By carefully observing and handling objects made of different materials, students will start to identify common characteristics, such as color and texture. They begin to develop the idea of matter having properties that can be used for sorting and describing. The focus in the younger grades is clearly on describing the nature and (to a limited extent) the behavior of matter. Experimenting with melting and freezing, for example, sets the stage for an understanding of the states of matter.

By the middle grades, students will realize that many objects are, in fact, combinations of different substances. The notion of how small pieces of matter join together as mixtures or compounds can be used to introduce the concept of forming new substances with new properties. The idea of chemical vs. physical change—an elusive concept at this age—can be introduced but will not be fully understood. Likewise, any discussion of atoms, elements, and molecules should not be expected to lead to a complete understanding of atomic structure.

It is in the upper grades that the atom and its constituent parts can serve as the basis for understanding chemical properties, chemical changes, and the nature of bonding between atoms to form molecules. The periodic table of elements becomes meaningful as a more sophisticated comprehension of the nature and structure of the atom emerges. The processes involved in activity at the atomic and molecular level can be discussed in the context of the various types of chemical reactions and the conditions that influence those reactions.

On the way to the achievement of this standard, students should also come to appreciate the practical aspects of knowing what their world is made of, and also to recognize how important scientific ideas are born and developed. The history of the development of our present-day understanding of the atom provides an outstanding example of the emergence and growth of scientific knowledge.

Descriptive Statement

Exploring the nature of matter and energy is essential to an understanding of the physical universe. This standard leads students from their experiences with the states and properties of matter to the development of atomic models and the underlying principles of chemistry.

CUMULATIVE PROGRESS INDICATORS

By the end of Grade 4, students

1. Describe and sort objects according to the materials from which they are made and their physical properties.

2. Recognize that matter can exist as a solid, liquid, or gas, and can be transformed from one state to another by heating or cooling.

3. Investigate matter by observing materials under magnification.

Building upon knowledge and skills gained in the preceding grades, by the end of Grade 8, students

4. Identify characteristic properties of matter, and use one or more of those properties to separate a mixture of substances.

5. Show how substances can react with each other to form new substances having characteristic properties different from those of the original substances.

6. Know that all matter is made up of atoms that may join together to form molecules, and that the state of matter is determined by the arrangement and motion of the atoms or molecules.

7. Explain how atoms are rearranged when substances react, but that the total number of atoms and the total mass of the newly formed substances remains the same as that of the original substances.

8. Explain that over 100 different atoms, corresponding to over 100 different elements, have been identified and can be grouped according to their similar properties.

Building upon knowledge and skills gained in the preceding grades, by the end of Grade 12, students

9. Know that atoms consist of a nucleus surrounded by electrons, and that the arrangement of the electrons determines the chemical behavior of each element.

10. Know that the nucleus consists of protons and neutrons, and that each atom of a given element has the same number of protons but that the number of neutrons may vary.

11. Explain how atoms can form bonds to other atoms by transferring or sharing electrons.

12. Demonstrate different types of chemical reactions and the various factors affecting reaction rates.

13. Explain how the *Periodic Table of Elements* evolved and how it relates atomic structure to the physical and chemical properties of the elements.

LIST OF LEARNING ACTIVITIES FOR STANDARD 8

GRADES K-4

Indicator 1:

GRADES K-2
Sorting Buttons
Mystery Liquids
Gases

GRADES 3-4
Floating Columns
Cabbage Juice

Indicator 2:

GRADES K-2
Is Sawdust Wood?
Sugar Cubes and Rock Candy
Comparing Liquids
Examining a Gas

GRADES 3-4
Changes of State with Butyl Stearate
Thermometers
Rate of Evaporation

Indicator 3:

GRADES K-2
Using Magnifiers
Salt, Sugar, and Pepper

GRADES 3-4
Magnifier Projects

GRADES 5-8

Indicator 4:

GRADES 5-6
Density of Floating Objects
Paper Chromatography
Magnetic Separation
Floating Flag
Properties of Powders

GRADES 7-8
Solubility
Melting Points/Boiling Points
Rock Properties
Thermal Conductivity
Breaking Strength

GRADE 8 ONLY
Sludge Test
Sludge—A Practical Application

Indicator 5:

GRADES 5-6
Chemical Changes
Acid-Base Reactions

GRADES 7-8
Introduction to Ionic Reactions
Types of Reactions
Composition Reactions: Oxidation of Metal
Single Replacement Reactions
Compounds of Oxygen

Indicator 6:

GRADES 5-6
Paper Clip Molecules

GRADES 7-8
Bread Box Phase Change

Indicator 7:

GRADES 5-6
[no activities]

GRADES 7-8
Introduction to Conservation of Mass
Types of Reactions, Revisited

Indicator 8:

GRADES 5-6
Introduction to the Periodic Table
Periodic Properties of Elements

GRADES 7-8
Building a Periodic Table
History of Periodic Chart

GRADES 9-12

Indicator 9:

Electron Configuration
Spectral Analysis

Indicator 10:

Isotopes

Indicator 11:

Chemical Bonds

Indicator 12:

Reaction Rates
Catalyst

Indicator 1: Describe and sort objects according to the materials from which they are made and their physical properties.

LEARNING ACTIVITIES: Grades K-2

Sorting Buttons. Students observe similarities and differences in buttons made from a wide variety of materials. They develop a scheme for sorting buttons made of wood, plastic, different-colored metals, and other materials. For example, they can organize buttons according to size or color.

Mystery Liquids. Children describe different mystery liquids (e.g., corn syrup, cooking oil, water, vinegar) by their properties. Challenge students to detect differences in color, odor, flow, and surface tension as they try to float a paper clip. Afterwards, they try to match an unknown liquid to the ones they have described.

Supporting Educational Research: *Benchmarks,* p. 76 (4B)
Related Workplace Readiness Standards: 3.9, 3.12, 3.4, 4.2

Gases. Students fill a plastic bag with air and contrast the properties of the air-filled bag with the properties of a bag filled with solid objects. If weight is mentioned as a big difference between the two bags, use a plastic bag filled with Styrofoam™ pieces to show that solid things can also be light.

- Using a hand pump, gently blow air at the students' hands (so they feel air move) and at different objects in the classroom. The students can use this pump to fill up a balloon. Then fill a balloon with helium, and ask what will happen if the air balloon and helium balloon are released at the same time. Students predict and then verify or modify their ideas.

- Obtain some big syringes (without needles) and tubing that will fit the ends of the syringes. Provide each pair of students with two syringes and one piece of tubing. After the students connect the two syringes with tubing, instruct them to push on the plungers. They will discover that the air in one syringe can move things in the other. Challenge them to observe as many things as possible about the air inside.

- Next, students put water into one of the syringes. They will soon discover that the water can be moved from one syringe to another. Ask them to describe the similarities and differences between the air movement and the water movement.

Related Science Standards: 2, 4
Related Workplace Readiness Standard: 3

LEARNING ACTIVITIES: Grades 3-4

Floating Columns. In this activity, students use floating columns to sort objects by their densities. Students pour liquids of varying densities (e.g., strong cold coffee, alcohol, glycerine, corn syrup) on top of each other in a graduated cylinder. Give students a collection of small objects that float at different levels. They carefully drop these objects one at a time into the column and observe each object's position after it settles in one of the liquid layers. In this way, they observe a relative density for the objects.

Supporting Educational Research: *Benchmarks,* p. 76 (4B)
Related Science Standard: 2
Related Workplace Readiness Standards: 3.9, 3.12, 5.5, 5.6

Cabbage Juice. Provide students with red cabbage juice and permit them to mix it with a variety of nontoxic household products such as alcohol, vinegar, lemon juice, dissolved antacids, baking soda, and salt water. Challenge students to put the liquids into categories relative to the color they produced when mixed with the red cabbage juice.

This activity presents a good opportunity to teach eye safety in lab.

Related Science Standards: 2-4, 7
Related Workplace Readiness Standards: 3.7-3.9, 4.2

Indicator 2: Recognize that matter can exist as a solid, liquid, or gas and can be transformed from one state to another.

LEARNING ACTIVITIES: Grades K-2

Is Sawdust Wood? Students examine pieces of different types of wood (e.g., pine, oak, walnut). Using sandpaper, they change the shape of each piece of wood and make individual piles of sawdust. Ask the students questions such as

- Are the different piles of sawdust made from the wood you sanded?
- What is your evidence?

Next, students use magnifiers to examine shavings (not the sawdust) of the original woods all mixed together. (Prepare these shavings before class begins.) The students compare and contrast the shavings with the woods with respect to the following:

- color
- smell
- hardness

Ask the students how many different woods they think are present in the mixture. Challenge them to separate the shavings and then match the shavings to the original wood pieces. Afterwards, discuss the evidence for the matches. Help students decide if the sawdust and wood shavings were once part of each type of wood.

At some point, a discussion of where wood comes from or an appropriate field trip might be beneficial.

Related Science Standards: 2, 4
Related Workplace Readiness Standards: 2.1, 2.2, 2.7, 3.9, 3.15, 4.9, 5.4, 5.6, 5.7

Sugar Cubes and Rock Candy. Using magnifiers, students compare and contrast sugar cubes and rock candy. After examining the two materials, they grind each one up separately using a mortar and pestle, if available. (Remind them to wear goggles.) It will be obvious to the students that one material is harder than the other. The students observe the ground-up substances, comparing and contrasting what they see and smell. Do the two materials have a similar appearance?

Students predict what will happen if the materials are dissolved in water. Discuss their predictions. After the materials dissolve in the water, discuss how the evidence proves or disproves their predictions.

Next, students predict what will happen if samples of both solutions are allowed to dry. Then, after the solutions dry, discuss how the evidence proves or disproves their predictions. Was the rock candy a different form of sugar?

Related Science Standards: 2, 4
Related Workplace Readiness Standards: 2.1, 2.2, 2.7, 3.9, 3.15, 4.9, 5.4, 5.6, 5.7

Comparing Liquids. Give students small samples of various liquids (e.g., liquid starch, mineral oil, corn oil, vinegar, and water) that were poured from labeled larger bottles. (Do not let them know which of the larger bottles was the source of each sample.) The students carefully pour the liquids into compartmentalized trays so no mixing can occur. To help control spillage, keep in mind the following hints:

- Use a small squeeze bottle (with a cap) for each liquid.
- Plastic ice-cube trays work well as compartmentalized trays.
- Use a larger tray under the compartmentalized tray to capture any spilled liquids.
- Have sponges handy for spills.

Establish the idea of *property*. Let students observe and record the properties of each liquid (e.g., color, clarity, smell, slipperiness). They try to determine which bottle each of their liquids came from and see how many of their samples they can correctly match.

Give the students a mystery liquid (e.g., methyl cellulose), and ask them to compare and contrast it with the other liquids. They determine which liquid seems closest to the mystery liquid, and if the mystery liquid is one of the other liquids. The students present the evidence for their decision.

Related Science Standards: 2, 4
Related Workplace Readiness Standards: 2.1, 2.2, 2.7, 3.9, 3.15, 4.9, 5.4, 5.6, 5.7

Examining a Gas. Place a few drops of rubbing alcohol on one hand of each student. Place a few-drops of water on the other hand. Ask the students to observe what happens. Explain that the liquids are becoming gases. Caution students about smelling the alcohol.

Ask students how they can increase the rate at which the liquids evaporate. Try any experiments they suggest. Most students will suggest blowing on their hands or waving their hands.

Do students think that the alcohol and water have disappeared? Place some water in sealed jars and some rubbing alcohol into other sealed jars. What happens? Place water in open containers around the room. In what location does the water evaporate faster? Does the water disappear or just go someplace else?

Place some perfume on a cloth on a desk. Ask students to raise their hand when they first smell the perfume. Ask them if they noticed where the hands went up first and where they went up last. Does this indicate that the perfume (and other gases) just disappear or do they go someplace else?

Finally, set up water cycle jars. The water in the bottom may or may not appear less, but water will appear all over the inside of the jars. Ask students to observe what happens. How does the water get on the inside surfaces? They can set up experiments to prove or disprove their ideas.

Note: Rubbing alcohol will hurt if placed on a cut or scratch on a student's hand. Perfume may bother some students with allergies or asthma.

Related Science Standard: 2
Related Workplace Readiness Standard: 3

LEARNING ACTIVITIES: Grades 3-4

Changes of State with Butyl Stearate. Students brainstorm the properties of water and list them on the board. Using normal safety precautions, they experiment with butyl stearate to determine its properties and how they compare with the properties of water.

Note: Some properties of butyl stearate will be immediately obvious. Other behavior will not be so obvious, such as reaction with food coloring and with water, and how butyl stearate evaporates.

In their logs or journals, students predict the effect of cooling butyl stearate. They cool a sealable plastic bag of butyl stearate by placing it in ice water. The bag should be stapled several times above the seal. They then describe what happens as the butyl stearate changes phase and compare their predictions with their observations. Discuss what happened. Ask the students questions such as the following:

- Where is the liquid butyl stearate now that it is a solid?
- How have the properties changed?
- Is the resulting solid butyl stearate?

Next, the students use warm water to melt butyl stearate. Is the melted substance the same as the solid substance? Introduce the idea of changing phase or state, and discuss the three phases of matter. Discuss other liquids that the students know can be both solids and liquids.

Discuss alternative ways to melt a bag containing butyl stearate (e.g., students' hands are warm enough to melt butyl stearate) and ways to separate a mixture of butyl stearate and water. Caution the students not to open the bag.

Students mix small amounts of water and butyl stearate in a sealable plastic bag stapled several times above the seal. First, they predict what happens when the bags are cooled. As they cool the mixture in buckets of ice water, the butyl stearate becomes solid. After separating the two substances, discuss with the students why the separation works. Could butyl stearate be reused if it became mixed with water? Discuss recycling as a process.

Related Science Standards: 2, 4
Related Workplace Readiness Standards: 2.1, 2.2, 2.7, 3.9, 3.15, 4.9, 5.4, 5.6, 5.7

Thermometers. Using thermometers, students measure the temperature of ice and water systems (mixtures). They keep records of the water temperature as the ice melts. Discuss what is happening and how we know ice and water are two different forms of the same thing. The students will observe that the ice/water temperature remains constant as long as there is sufficient ice in the water.

Water droplets may appear on the outside of the container. At what temperature did these droplets appear? Ask students where this water came from. Discuss the evidence.

Note: Cross-connect with "Condensation," a learning activity for Science Standard 10, Indicator 3.

Related Science Standards: 2, 4
Related Workplace Readiness Standards: 2.1, 2.2, 2.7, 3.9, 3.15, 4.9, 5.4, 5.6, 5.7

Rate of Evaporation. Students carefully pour water and corn oil into separate baby bottles with calibrations on the side. After measuring the volume of each liquid, allow the mixture to evaporate over several days. Periodically record the room temperature near the bottle. After a few days, the students measure the volume of each liquid. The students can use calculators to determine the rate of evaporation.

Using charts or graphs, the students can display changes in temperature and/or volume.

Related Science Standards: 5, 10, 12
Related Workplace Readiness Standards: 3.1, 3.3, 3.9, 3.10

Indicator 3: Investigate matter by observing material.

LEARNING ACTIVITIES: Grades K-2

Using Magnifiers. Students use magnifiers to look at a variety of objects such as spices, poppy seeds, salt crystals, and cork. Some suggested magnifiers include

- a tripod magnifier (ideal for the primary grades)
- a sturdy plastic bag filled with water
- water in jars of various sizes
- magnifying boxes

Magnifying boxes are especially useful for examining things that need to be contained, such as soil samples (to avoid spills) or insects that may be harmful to students or harmed by students. (Remember to release a living insect after a short time.)

Salt, Sugar, and Pepper. Students examine salt, sugar, and pepper with just their eyes and then with magnifying glasses. The advantages of the lens will be immediately apparent. (Warn them that inhalation of these materials may cause sneezing.) The students record the properties of each substance in their log or journal.

Students mix small amounts of the salt, sugar, and pepper together on small trays. Their job now is to separate them by appearance. Provide spoons, plastic stirrers, and magnifiers. At some point, the students should realize that the salt has a cube shape and the sugar does not. The pepper will be easy to separate because of its color.

Next, the students place the salt, sugar, and pepper into water. They observe what happens. Ask them questions such as

- Is the salt, sugar, and pepper still in the water?
- Can you see anything with a magnifier?
- What will happen if you let the water evaporate?

After the liquid evaporates, ask questions such as

- Is the white powder that remains just salt, just pepper, just sugar—or a mixture of each? How can you tell?
- What evidence suggests that the remaining powder is or is not salt? sugar? pepper?

Related Science Standards: 1, 3
Related Workplace Readiness Standards:2.1, 2.2, 3.9, 3.15, 4.2, 4.9, 5.1, 5.4, 5.7

LEARNING ACTIVITIES: Grades 3-4

Magnifier Projects. Using handheld microscopes or magnifiers, students examine a variety of objects to detect similarities and differences.

- *Sand and Soil*—First, students examine sand in sealable plastic bags from various places to discover if all the sands are the same. Next, they look at top soil and subsoil (also in sealable plastic bags) from the same land location. They try to detect any differences between the two soils. By placing a clear plastic metric ruler next to an object under the handheld scope or magnifier, the students can measure the size of objects.

- *Eyes*—Students carefully examine the color portion of a partner's eyes. Brown eyes and blue eyes have easily seen spots of color that vary from person to person.

- *Five-dollar bill*—An interesting related activity is to have students examine a five-dollar bill magnified to find the name of the original 13 colonies (at the top of the columns).

- *Dust and lint*—Students look for dust and lint in the room. (Since this may be a sensitive issue and a health concern, use discretion.) They describe the kind of dirt they find in corners, near the door, and on the floor. Do different kinds of dirt exist in different places, or is all dirt the same? Ask students how they would suggest capturing each form of dirt so there would be less dirt next week at the same time.

Related Science Standards: 1, 3
Related Workplace Readiness Standards:2.1, 2.2, 3.9, 3.15, 4.2, 4.9, 5.1, 5.4, 5.7

Indicator 4: Identify characteristic properties of matter, and use one or more of those properties to separate a mixture of substances.

LEARNING ACTIVITIES: Grades 5-6

Density of Floating Objects. The density of materials is an important concept. Students investigate this concept by comparing densities. First, they compare

- objects of similar size—on opposite sides of a balance (same size, different mass)
- objects of varying sizes but similar masses—in water (some that float vs. some that sink)

Next, students make a floating object stay just at the surface by attaching paper clips or small tacks. Finally, students form equal masses of clay into several different shapes (including at least one clay boat) to see if the shape changes the density.

Related Science Standards: 1, 2, 5, 10
Related Workplace Readiness Standards: 3.3, 3.9, 3.14, 5.4, 5.7

Paper Chromatography. Students learn about the varying complexity of molecules during this activity. Paper chromatography is a simple way for students to separate the pigments in a dye such as Magic Marker™ ink, Kool-Aid®, or food coloring. Using paper towels, a solvent (water, alcohol, a mixture), a tall glass or plastic cup, and a dye solution, they separate two or more types of substances (molecules) from the mixture.

Students create a chart of the colors separated and plot the time it took for each color to climb the paper towel using different solvent solutions.

Related Science Standards: 2, 4, 5
Related Workplace Readiness Standards: 3.3, 3.9, 3.12, 5.4, 5.7

Magnetic Separation. Provide students with a variety of items, including those composed of the following materials:

- iron, steel, and other metals
- wood
- plastic
- glass

Students sort the items based on magnetic attraction, then they discuss why there are differences in the materials. Ask them how this type of sorting process is used in a junkyard.

Related Science Standards: 1, 2, 9
Related Workplace Readiness Standards: 3.9, 3.12, 5.4, 5.7

Floating Flag. Students investigate the concept of density in liquids. They float colored liquids on top of each other to produce a floating flag for holidays or special events. Use liquids such as the following:

- orange-tinted alcohol
- colorless oil
- green-colored water

Afterwards, miscibility could be a secondary discussion as students shake the liquids and the colors change.

Related Science Standard: 2
Related Workplace Readiness Standards: 3.2, 3.7, 3.8, 5.4, 5.7

Properties of Powders. Students identify a series of common, white powders found in the home (especially the kitchen) by observing/testing chemical and physical properties. Characteristic properties recorded include the following:

- color
- texture
- microscopic crystal structure
- reaction with common substances such as water, alcohol, iodine, and/or vinegar
- reaction to heat

They first test known household substances and then identify an unknown.

As an extension activity, the students can prepare water solutions of each powder and test the solutions for acidity using cabbage juice or other indicator.

Supporting Educational Research: EES Mystery Powders Lab
Related Science Standard: 2
Related Workplace Readiness Standards: 3, 4, 5

LEARNING ACTIVITIES: Grades 7-8

Solubility. Solubility is a property that can be used to identify substances. In this activity, students prepare solutions using various combinations of solids and liquids. By measuring the volume of substances used, they learn about the concept of concentration. Students also investigate insoluble or immiscible combinations, such as oil and water, or alcohol and salt.

Related Science Standards: 2, 5
Related Workplace Readiness Standards: 3.1, 3.9, 5.4, 5.7

Melting Points/Boiling Points. Using a thermometer, students determine the melting points and/or boiling points of water. They then graph temperature vs. time. The melting and boiling plateaus illustrate the heat of fusion and heat of vaporization of the liquids.

Related Science Standards: 2, 5, 9
Related Workplace Readiness Standards: 3.7, 3.9, 3.12, 5.4, 5.7

Rock Properties. Students sort a collection of rocks or minerals by color, texture, streak, cleavage, density, or Mohs' scale reading. Next, using a different property, they re-sort the same group of rocks or minerals. By sorting and re-sorting the rocks or minerals using different criteria, students learn how different properties could be used in different circumstances.

As an extension activity, students can decide which rock/mineral could be used for each of the following: buildings, roads, statues, steps, sidewalks, jewelry, and cutting devices.

Related Science Standards: 2, 10, 11
Related Workplace Readiness Standards: 3.7, 3.12, 5.4, 5.7

Thermal Conductivity. To illustrate the concept of thermal conductivity, students use several different types and/or gauges of metallic wire. Wearing safety goggles, they place one drop of wax every 5 to 8 cm on the metallic wire, then heat one end of the wire with a candle or Bunsen burner. They time the melting of each wax drop and graph distance vs. time in order to compare different metallic wire types and/or gauges.

As an extension, ask the students to decide what type of chair they would prefer sitting on during a sunny summer afternoon.

Related Science Standards: 2, 5, 9
Related Workplace Readiness Standards: 3.7, 3.8, 5.4, 5.7

Breaking Strength. Students test the strength of wire (metal, plastic, or fiber) by connecting a wire across an open space and then suspending objects from the center of the wire. Students graph the mass each wire holds.

As an extension activity, students double, braid, or combine wires to improve strength. Ask them if the strength is proportionately increased as they increase the number of strands.

Related Science Standards: 2, 5, 9
Related Workplace Readiness Standards: 3.6, 3.7, 3.13, 5.4, 5.7

LEARNING ACTIVITIES: Grade 8

Sludge Test. Give students a "sludge" containing a mixture of soluble and insoluble solids and liquids. To determine the identity of each substance, students use characteristic chemical and physical properties such as

- magnetism
- ductility
- density
- boiling point
- freezing and melting points
- solubility
- reactions to heat and known chemicals
- flame tests

They keep a log of the processes and tests used. In their report, they discuss the reasons for each step of their experimental procedure.

Sludge—A Practical Application. After students have performed the above tests, give them the following problem to solve:

> "As you walk in the woods near a lake, you notice a strange-colored area in the water. Upon closer inspection, you observe that the spot is actually a streak through the lake that comes from the north. You know that in the north there is a fertilizer factory that produces sodium and potassium compounds. As a creative and curious student, you carefully bring back this sludge, which appears to be made of more than one liquid and possibly some solids. How would you find out as much as possible about each of the substances in the mixture? How would you find out if the pollution was coming from the fertilizer factory? Write the steps you would take (as simply as possible). List the specific tests you would perform and the appropriate order. Explain the reasons why you will use these tests, and describe the anticipated results."

Supporting Educational Research: Modeled on the IPS sludge test
Related Science Standard: 2
Related Workplace Readiness Standards: 3, 4, 5

Indicator 5: Show how substances can react with each other to form new substances having characteristic properties different from those of the original substances.

LEARNING ACTIVITIES: Grades 5-6

Chemical Changes. Students investigate several types of chemical reactions and observe changes both in properties and in mass. (Be sure to emphasize proper personal safety to the students.) The following are among the more interesting reactions that can be observed safely at this age:

- burning paper
- rusting iron
- bleaching cloth
- removing tarnish from silver
- vinegar and baking soda
- pennies in salt water
- iron nail in Miracle-Gro
- metal with acid
- a seashell and vinegar

Students make observations before, during, and after the reactions and compare properties and masses where possible. (The mass of the reactants is easy to determine in self-locking bags.) What evidence is there that a chemical change has occurred? To stimulate class discussion, ask students about the helpfulness/benefits vs. the destructiveness of chemical reactions.

Related Science Standards: 1, 2, 10, 12
Related Workplace Readiness Standards: 3.3, 3.11, 3.14, 4.7, 5.7

Acid-Base Reactions. Students use a nontoxic acid-base indicator to help them observe acid-base reactions. They add a specific amount of the indicator to equal volumes of vinegar (an acid) and household ammonia (a base) and observe the color changes. Then the students mix the two solutions. The resulting color changes show that the properties of the compounds have changed.

As an extension activity, students can discuss acid rain and its effects on ecosystems.

Related Science Standards: 2, 5, 10, 12
Related Workplace Readiness Standards: 3.7-3.9, 5.4, 5.7

LEARNING ACTIVITIES: Grades 7-8

Introduction to Ionic Reactions. In this activity, students determine if ions are present in dilute solutions of household chemicals. They use a conductivity device to check for the presence of ions in the solutions. In this way, they determine whether ionic reactions are possible for certain combinations of chemicals.

As an extension activity, the students discuss the environmental safety of the household chemicals used.

Related Science Standards: 2, 12
Related Workplace Readiness Standards: 3.6-3.9, 3.11, 3.14, 5.4, 5.7

Types of Reactions. Students observe a variety of chemical reactions in this activity, writing down the equations of each reaction.

- They combine two solutions that form a solid when mixed together (e.g., iron II chloride and silver nitrate).
- They place calcium carbonate in a test tube, which they close with a balloon. They heat the mixture gently until it begins to react. They compare the product to the original reactants.
- They perform the electrolysis of water experiment, in which they break water into hydrogen and oxygen find the volume of the two gases convert the volume to mass using density measurements compare the characteristic properties of both gases using a flame test

Note: "Types of Reactions" can also be used for indicator 7 if students mass all the products and reactants involved in the experiments.

Related Science Standards: 2, 5
Related Workplace Readiness Standards: 2.2, 3.1-3.15, 4.1, 4.9, 5.4, 5.5, 5.7

Composition (Synthesis) Reactions: Oxidation of Metal. The oxidation of metal is an example of a composition reaction. This common reaction produces a new material that is visually different. Students investigate the oxidation of iron filings to iron oxide by exposing granular iron or iron filings to a strong oxidizing agent, such as Clorox™ bleach, and observing the formation of a new substance. This reaction yields a change in mass.

As an extension (or alternate) activity, students can observe the oxidation of zinc or the tarnishing of silver after touching the metal to a hard-boiled egg. Is there a difference in reaction caused by touching the egg white as opposed to the egg yolk?

Related Science Standards: 2, 10
Related Workplace Readiness Standards: 3.1, 3.8, 3.11, 5.4, 5.7

Single Replacement Reactions. The reaction of aluminum with a dilute solution of copper II chloride dramatically illustrates a single replacement reaction. After observing the properties of aluminum foil, water, and copper II chloride, the students mix the water and copper II chloride and record their observations. Next, they form the foil into a boat and float it in the solution. They record follow-up observations for several minutes and then again the next day. Does the evidence show a chemical reaction? The resulting phenomena should initiate a lively class discussion.

Related Science Standard: 2
Related Workplace Readiness Standards: 3.7-3.12, 5.4, 5.7

Compounds of Oxygen. Oxygen forms compounds with many elements, producing compounds with distinctly different properties. When oxygen reacts individually with magnesium, hydrogen, and carbon, the resulting compounds are a solid, a liquid, and a gas, respectively. Students research the chemical and physical properties of these new compounds.

Paper clips of different colors and shapes can be used to model the molecules of the oxygen compounds formed.

As an extension activity, students can combine other elements using the paper clips and research the properties of the resulting compounds.

Related Science Standards: 2, 12
Related Workplace Readiness Standards: 3.6-3.9, 5.4, 5.7

Indicator 6: Know that all matter is made up of atoms that may join together to form molecules, and that the state of matter is determined by the arrangement and motion of the atoms or molecules.

LEARNING ACTIVITIES: Grades 5-6

Paper Clip Molecules. Students use paper clips of two different shapes or sizes to assemble a molecule from its component elements. Each student is given three pairs of similar paper clips and one pair that are different and is asked to arrange these into two identical models that use all of the paper clips. After several tries students will notice that there are a number of possible arrangements but only one is correct.

Related Science Standard: 5.1, 5.2, 5.9
Related Workplace Readiness Standards: 3.7, 3.8, 3.9, 3.14

LEARNING ACTIVITIES: Grades 7-8

Bread Box Phase Change. Using a small "bread box" device, have students stand the box on its end and trace the arrangement of the breads inside of the box. Have students slowly rotate the box and trace/draw the movement of the molecules as represented by the beads. The students then vibrate the box and draw the molecules (beads) as they are in motion.

Student groups discuss the different movements they observed and relate these to solids, liquids and gaseous phases of matter. A class discussion may follow.

(*A box is approximately a 10cm x 60cm x 1 cm clear plastic box which can be sealed with 20-30 small plastic or glass beads.)

Related Science Standard: 5.1, 5.1, 5.9
Related Workplace Readiness Standards: 3.7, 3.8, 3.9, 3.14

Indicator 7: Explain how atoms are rearranged when substances react, but that the total number of atoms and the total mass of the newly formed substances remain the same as that of the original substances.

LEARNING ACTIVITIES: Grades 7-8

Introduction to Conservation of Mass. As an introduction to the law of conservation of mass, students use paper clips of different shapes to represent reacting elements in a reaction. Students then reorganize the paper clips to represent the products. For example, three hydrogen molecules (three pairs of standard paper clips) reacting with one nitrogen molecule (one pair of butterfly clips) produces two ammonia molecules (two groupings of three paper clips attached to a butterfly clip). Measuring the mass of the paper-clip reactants and products would reinforce the law of conservation of mass.

Related Science Standard: 5
Related Workplace Readiness Standards: 3.2-3.2

Types of Reactions, Revisited. Students observe a variety of chemical reactions in this activity, writing down the equations of each reaction. They measure the mass of all the reactants before and after the experiments.

- Combine two solutions that form a solid when mixed together (e.g., zinc nitrate and sodium hydroxide).
- Combine baking soda and vinegar in a sealable plastic bag. (Experiment with amounts first!)
- Pour hydrogen peroxide in a sealable plastic bag, and place the bag in the sunlight.
- Put a damp nail in a sealable plastic bag, and leave the bag in the sunlight for several hours.

Related Science Standards: 2, 5
Related Workplace Readiness Standards: 2.2, 3.1-3.15, 4.1, 4.9, 5.4, 5.5, 5.7

Indicator 8: Explain that over 100 different atoms, corresponding to over 100 different elements, have been identified and can be grouped according to their similar properties.

LEARNING ACTIVITIES: Grades 5-6

Introduction to the Periodic Table. In this activity, students create an analogy to the periodic table of the elements. Each student records pertinent information about themselves on 3-by-5-inch cards. Information might include the following:

- height
- eye color
- hair color
- birthday
- favorite hobby

The class puts together the entire chart on a bulletin board. (Alternately, these cards can be duplicated and a set given to each student group.) The entire class (or individual groups) then organize the cards into rows and columns by using two or three of the facts. The students can reorganize the cards again and again using different groupings of facts. This exercise easily leads into a class discussion of the properties of the elements and their arrangement on the periodic table of the elements.

Related Science Standards: 1, 2
Related Workplace Readiness Standards: 3.6-3.15, 4.2, 4.4, 4.5

Periodic Properties of Elements. When elements are arranged in order of increasing atomic number, they exhibit a periodic recurrence of properties. Students can document periodic trends in certain properties, such as density and solubility, of compounds that contain elements in the same group. In this activity, students measure the densities of certain elements and the solubilities of certain salts. They then describe the periodic variation of the compounds.

Related Science Standard: 2
Related Workplace Readiness Standards: 3, 4, 5

LEARNING ACTIVITIES: Grades 7-8

Building a Periodic Table. The arrangement of elements on the periodic table can be illustrated by the use of an element deck of cards. Each card includes the name and/or symbol of an element as well as several of its properties, such as

- melting point
- atomic mass
- color
- atom size
- activity ranking

Remove some of the cards from the deck. Working in small groups, the students arrange the remaining cards into columns or rows by using one or two of the properties. Groups compare their combinations, and the class constructs a master chart on a bulletin board or wall. Students then compare this master chart to either Mendeleyev's chart or the modern version. The class may then discuss "misplacements" or missing cards and debate if other information is missing or if changes need to be made.

Related Science Standards: 1-3
Related Workplace Readiness Standards: 3.6-3.13

History of Periodic Chart. Working in small groups, students research the life and discoveries of a chemist who was involved in the development of the periodic chart (1800 to present). Each group develops a visual to represent the chemist's contribution to the modern periodic chart.

Related Science Standards: 3-5
Related Workplace Readiness Standards: 3.5, 3.8-3.10, 3.14, 4.2, 4.7, 4.9-4.11

Indicator 9: Know that atoms consist of a nucleus surrounded by electrons, and that the arrangement of the electrons determines the chemical behavior of each element.

LEARNING ACTIVITIES: Grades 9-12

Electron Configuration. Give each student group a deck of cards that contain only the atomic number of an element and its electron configuration. Ask the groups to arrange the cards into logical groupings by using only the electron configuration. Groups compare their arrangements and work together to organize the cards into a classroom chart of element families that have similar chemical behavior.

As an extension or alternate exercise, students use the activity rankings or reactions with hydrogen and oxygen to produce a similar chart. As a follow-up activity, the students could choose an element family and test each member's reactions with a particular element or solution.

Related Science Standard: 2
Related Workplace Readiness Standards: 3.6-3.15

Spectral Analysis. Absorption and emission spectra are used to identify many elements. When elements are heated to high temperatures, they may be placed in an excited state. In this excited state, valence electrons move to higher energy levels. When the electrons return to their ground state, they may emit visible light of characteristic colors, which can be used to identify the element.

In this activity, students identify the colors of the emission spectra of some metallic ions—for example, Ca(NO3)2, Ba(NO3)2, NaNO3, SrNO3—using a burner and wood splints. After reviewing safety procedures, they place a small amount of the solid ionic compounds (about the size of a rice grain) in the tip of a wooden splint. The students place the splint at the edge of the hottest part of the flame (top of the inner blue cone). They observe the color with an unaided eye and with a spectroscope. They record the results in a table and include the name of the compound, the metal ion, and the color.

Give students an unknown. Challenge them to identify it by observing its spectrum and comparing their observations with the emission spectra table they developed earlier.

Related Science Standards: 8, 9
Related Workplace Readiness Standards: 3.6-3.9

Indicator 10: Know that the nucleus consists of protons and neurons, and that each atom of a given element has the same number of protons but the number of neutrons may vary.

LEARNING ACTIVITIES: Grades 9-12

Isotopes. Ask students to diagram isotopes of the first ten elements. Next, students research how isotopes of an element can be separated from each other. They should research C-14, H-3, and U-238 for their properties and uses.

Students may wish to use the Internet for this activity.

Related Science Standard: 2
Related Workplace Readiness Standards: 3.8, 3.13

Indicator 11: Explain how atoms can form bonds to other atoms by transferring or sharing electrons.

LEARNING ACTIVITIES: Grades 9-12

Chemical Bonds. Using electronegativities, the students determine the type of bond formed between two elements. From this information, they draw Lewis diagrams for ionic, polar, and covalent combinations. The students construct models of molecules for polar and covalent combinations using Styrofoam™ spheres and toothpicks. They determine molecular shapes, bond angles, and polarity of each molecule.

Related Science Standards: 1-3
Related Workplace Readiness Standards: 3.1-3.15, 4.2

Indicator 12: Demonstrate different types of chemical reactions and the various factors affecting reaction rates.

LEARNING ACTIVITIES: Grades 9-12

Reaction Rates. In this activity, students determine experimentally how factors such as concentration and temperature affect reaction rate. Emphasize quantitative results. Review safety procedures.

Consider demonstrating the reaction between solution A (potassium iodate, $KIO3$) and solution B (soluble starch, $Na2S2O5$) so the students know what to expect. (They may recall the iodine test for starch from previous biology classes.) However, avoid any discussion concerning preconceived ideas about the effect of concentration on rate before the students experiment with different temperatures and concentrations/dilutions.

Students may use water baths for this procedures, with 40°C as the highest value assigned. Assign each group a water-bath temperature. After students collect data, they make two graphs:

- time vs. concentration
- time vs. temperature

Ask students questions such as the following:

- What does the heat do to the molecules?
- What is the concentration of solution A ($KIO3$)?
- Which relationship (if any) was inverse? Which relationship (if any) was direct?
- What is the variable in each situation, and how do you control it?

Related Science Standards: 2, 4, 5, 8, 10
Related Workplace Readiness Standards: 3.1-3.15

Catalyst. Students estimate the number of bubbles produced by a small amount of hydrogen peroxide placed in a beaker. In another beaker, they add a *very small* amount of manganese dioxide to the hydrogen peroxide and repeat the count. Does the addition of manganese dioxide change the number of bubbles?

Related Science Standards: 2, 4, 5, 8, 10
Related Workplace Readiness Standards: 3.1-3.15

SCIENCE STANDARD 9

All students will gain an understanding of natural laws as they apply to motion, forces, and energy transformations.

INTRODUCTION

This standard forms the basis for an investigation of force and motion leading to an understanding of energy and energy transformation. By studying moving objects and the forces (visible and invisible) that cause them to move, students develop an understanding of the fundamental laws of motion along with the notion of kinetic and potential energy. All forms of radiant energy—such as heat, light, and sound—are simultaneously explored, first as observable phenomenon and eventually as qualities that can be described and measured mathematically. Key to the achievement of this standard is an understanding of the factors affecting the production, transfer, and conservation of energy.

DEVELOPMENTAL OVERVIEW

In grades K-4, a young child's world is a world of objects that are compared, described, and manipulated. Pushing, pulling, and dropping objects leads to an intuitive sense of what causes and controls motions, although the concept of motion is elusive at this age. Likewise, sources of heat, light, sound, electricity, and magnetism can be experienced and experimented with. At these grade levels, heat will not be distinguished from temperature, and the notion of action at a distance—forces such as magnetism, static electricity, and gravity—can be observed but not understood.

By grades 5-8, descriptions of motion can move from qualitative to quantitative, involving the determination and even the calculation of speed. Discussing the factors affecting speed will introduce the force of friction, which will be somewhat misunderstood as the concept of inertia begins to develop. The idea of energy will begin to take root, linked first with the motion of objects (mechanical energy). Continuing investigations of heat, light, sound, electricity and magnetism, and gravity will contribute to a more conceptual understanding of energy as something that has many forms and is constantly being transferred.

By grades 9-12, students are ready to deal with force, motion, and energy as phenomena that can be measured, calculated, and compared using mathematical expressions and equations. Laboratory investigations and descriptions of other experiments can help them understand the evidence leading to the laws of motion and the conclusion that energy is conserved. At this age, experiences should do more than confirm physical laws and principles. Students should be confronted with technological design problems where they can observe firsthand—and put to use—those principles and concepts associated with energy transfer.

DESCRIPTIVE STATEMENT

Basic principles of physics emerge in this standard, where the study of force and motion leads to the concept of energy. All forms of energy are introduced and investigated, and principles of transformation and laws of conservation are developed.

CUMULATIVE PROGRESS INDICATORS

By the end of Grade 4, students

1. Demonstrate that the motion of an object can vary in speed and direction.
2. Demonstrate that the position and motion of an object can be changed by pushing or pulling and that the change is related to the strength of the push or pull.
3. Recognize that some forces are invisible and can act at a distance.
4. Investigate sources of heat and show how heat can be transferred from one place to another.
5. Investigate sources of light and show how light behaves when it strikes different objects.
6. Demonstrate how sound can be produced by vibrating objects and how the pitch of the sound depends on the rate of vibration.
7. Demonstrate how electricity can be used to produce heat, light, and sound.

Building upon knowledge and skills gained in the preceding grades,
by the end of Grade 8, students

8. Explain how a moving object that is not being subjected to a net force will move in a straight line at a steady speed.
9. Show that when more than one force acts on an object at the same time, the forces can reinforce or cancel each other, producing a net force that will change the speed or direction of the object.
10. Investigate how the force of friction acts to retard motion.
11. Describe the various forms of energy, including heat, light, sound, chemical, nuclear, mechanical, and electrical energy and that energy can be transformed from one form to another.

12. Explain how heat flows through materials or across space from warmer objects to cooler ones until both objects are at the same temperature.

13. Explain that the sun is a major source of the Earth's energy and that energy is emitted in various forms, including visible light, infrared and ultraviolet radiation.

14. Show how light is reflected, refracted, or absorbed when it interacts with matter and how colors appear as a result of this interaction.

15. Show how vibrations in materials can generate waves which can transfer energy from one place to another.

Building upon knowledge and skills gained in the preceding grades, by the end of Grade 12, students

16. Explain the mathematical relationship between the mass of an object, the unbalanced force exerted on it, and the resulting acceleration.

17. Prove that whenever one object exerts a force on another, an equal amount of force is exerted back on the first object.

18. Know that gravity is a universal force of attraction between masses that depends on the masses and the distance between them.

19. Know that electrically charged bodies can attract or repel each other with a force that depends on the size and nature of the charges and the distance between them.

20. Explain the similarities and differences between gravitational forces and electrical forces that act at a distance.

21. Know that the forces that hold the nucleus of an atom together are stronger than electromagnetic forces and that significant amounts of energy are released during nuclear changes.

22. Explain how electromagnetic waves are generated, and identify the components of the electromagnetic spectrum.

23. Explain that all energy is either kinetic or potential and that the total energy of the universe is constant.

LIST OF LEARNING ACTIVITIES FOR STANDARD 9

GRADES K-4

Indicator 1:

GRADES K-2
Moving Objects

GRADES 3-4
Bike Riding
Rolling Objects down a Ramp
Marble Maze

Indicator 2:

GRADES K-2
Playing Tug-of-War
Flying Kites

GRADES 3-4
Arrows Represent Forces
Using an Inclined Walkway
Moving Toys
The Force of Wind

Indicator 3:

GRADES K-2
Magnet on Toy Car
Paper Clip on Thread
Magnetic vs. Nonmagnetic Classification

GRADES 3-4
Demonstrating Magnetic Fields
Magnetized Needle
Static Electric Fields
Gravitational Fields
Building Electromagnets
Compass Investigation
Falling Objects

Indicator 4:

GRADES K-2
Fluids in Motion
Heat Lamp
How Animals Keep Warm

GRADES 3-4
Air Currents
Chemical Sources of Heat
Partner Convection Experiments

Indicator 5:

GRADES K-2

Light Mystery Box
Different Color Lightbulbs
Totally Dark Room
Seeing through Rose-Colored Glasses
Mirror Cards
Light Striking Various Surfaces
Heating of Materials by Sunlight

GRADES 3-4

Water Drop Experiments
Light Beams
Colored Goggles
Convex and Concave Mirrors
Convex and Concave Lenses

Indicator 6:

GRADES K-2

Rubbing a Comb
Feeling Vibrations
Making Musical Instruments

GRADES 3-4

Seeing Sound Vibrations
Seeing Sound Waves
Making or Transmitting Sound

Indicator 7:

GRADES K-2

Speaker and Sound
Producing Heat with Electricity

GRADES 3-4

Nichrome Wire Experiments
Simple Circuit
Buzzers

GRADES 5-8

Indicator 8:

GRADES 5-6

Toy Car

GRADES 7-8

Inertia

Indicator 9:

GRADES 5-6

Tripod Pendulums
Modes of Transportation
Forces on an Airplane
Fluid Pressure

GRADES 7-8

Car Loop
Simple Machines

Indicator 10:

GRADES 5-6
Overcoming Friction
Parachute Car

GRADES 7-8
Surface Friction

Indicator 11:

GRADES 5-6
Energy and Communications Technology
Lewis Latimer

GRADES 7-8
Energy Transfer
Mall Physics
Power Plant Role-Play

Indicator 12:

GRADES 5-6
Heat Transfer

GRADES 7-8
Energy Efficiency
Freezing Water

Indicator 13:

GRADES 5-6
Solar Energy
The Greenhouse Effect

GRADES 7-8
Energy Technology
Energy Conservation
Receiving Wavelengths

Indicator 14:

GRADES 5-6
Periscope
Mirrors

GRADES 7-8
Lenses
Underwater

Indicator 15:

GRADES 5-6
Sound Travel through Solids
Sound Travel through a Liquid
Sound Travel through a Gas

GRADES 7-8
Straw Oboes
Straw Pipes

GRADES 9-12

Indicator 16:

Newton's First Law of Motion
Newton's Second Law of Motion

Indicator 17:

Newton's Third Law of Motion

Indicator 18:

Gravity and Distance

Indicator 19:

Electrostatics

Indicator 20:

Gravitational and Electrostatic Forces

Indicator 21:

Nuclear Physics

Indicator 22:

X Rays
Color
Uses of Electromagnetic Radiation
EMFs

Indicator 23:

Toys and Energy
Bouncing Balls
Heat Exchange

Indicator 1: Demonstrate that the motion of an object can vary in speed and direction.

LEARNING ACTIVITIES: Grades K-2

Moving Objects. Students assemble a variety of objects such as the following:

- things they can roll (e.g., toy cars)
- things they can drop (e.g., two pieces of paper, one kept flat and the other crumpled up in a ball)
- animals (including some humans)

After discussing safety issues related to movement, speed, and impacts, students allow the objects to move and then compare their movements. Challenge the students to answer questions like the following:

- Which piece of paper falls faster?
- How are the movements of those two objects alike? How are they different?
- Which toy car goes faster?
- What would be a fair test to determine which of the two toy cars goes faster?

Discuss with students how they can decide which one goes faster. Many students will feel that the car that travels farthest goes faster. This is not always true. Students will learn that the speed of an object depends not only on how far the object goes (*distance*) but also on the *time* it takes to go that distance.

Ask the students to try to make each car go faster or change its direction. By experimenting, students should conclude that a push or a pull (i.e., a *force*) is needed to change speed or direction.

Reading the story about the tortoise and the hare would be a good literature connection.

Supporting Educational Research: *Benchmarks*, p. 89
Related Science Standards: 2, 4, 5, 9
Related Workplace Readiness Standards: 3.12, 3.7, 5.3

LEARNING ACTIVITIES: Grades 3-4

Bike Riding. Ride a tricycle or small bicycle in class. (The sillier you look, the better students will remember the ideas!) Discuss how you can vary the speed and direction, do it, and then ask questions such as

- Can I make myself stop?
- How fast can I go?
- Will it be harder to stop if I go faster?
- How can I cover the longest distance in the shortest time?
- How much of a ramp can I go up?

The intent is to help students examine what caused the motion and what has to happen to change any motion. Ask students to describe what they see happening. They can then set up experiments as appropriate. Discuss safety issues related to movement, speed, and impact.

Rolling Objects down a Ramp. Working cooperatively in groups, students take pieces of wood (about 2 ft by 4 ft) and make ramps, using books to prop up the wood pieces. They roll a can, model car, or ball down the ramp after predicting about how far the object will go. They keep records of actual distance covered and the time it took to cover that distance. Next, the students increase the angle of the ramp. They allow the can (or car or ball) to roll once more, again keeping records. As they increase the angle, the object rolls farther in less time. Once students realize the relationship between distance and time, discuss the concept of speed. Also discuss safety issues related to movement, speed, and impact.

Marble Maze. This challenge focuses on the concepts of motion, gravity, and the controlling of speed and direction. Give each group of students a board (approximately 2 ft by 4 ft). Ask them to design and construct a ramp on which a marble will roll from a high point to a low point. By adding hills, valleys, and other obstacles, they must cause the marble to take the longest possible time to roll from the top of the ramp to the bottom. Students keep a design journal throughout the activity to record their actions as well as design successes and failures.

Supporting Educational Research: Benchmarks: p. 89
Related Science Standards: 2, 4, 5, 9
Related Workplace Readiness Standards: 3.12, 3.2, 4.2, 5.3

Indicator 2: Demonstrate that the position and motion of an object can be changed by pushing or pulling and that the change is related to the strength of the push or pull.

LEARNING ACTIVITIES: Grades K-2

Playing Tug-of-War. As students play tug-of-war, point out that if both teams pull equally hard, the rope does not move. Discuss how forces must be uneven to cause a change in movement. Be sure to use a strong enough rope and follow safety procedures.

Flying Kites. Students' kite flying dramatically shows the effects of wind as a force that can change the motion of an object. Students can use a simple fan to help them design small kites. They use weather forecasts to identify days in the coming week that might be best for kite flying. In this way, a study of forces and motion can be related to their understanding of weather.

Supporting Educational Research: Benchmarks: pp. 89, 94
Related Science Standards: 2, 4, 5, 9
Related Workplace Readiness Standards: 3.3, 5.3, 5.4

LEARNING ACTIVITIES: Grades 3-4

Arrows Represent Forces. Draw diagrams using arrows to indicate the direction of each obvious force acting on an object. The length of each arrow indicates the amount of the force. The longer the arrow, the greater the force. Ask the students questions such as the following:

- What can you tell about the forces on an object that is sitting still?
- What happens if the object is already moving and the forces are equal in all directions?

Write a series of examples on the board using arrows representing all possible forces pushing on a box. Let students determine whether the object will move and in what direction. A simple computer simulation program would be useful.

Using an Inclined Walkway. Have students try to push or pull a loaded wagon up an inclined walkway. Let them experiment with different loads to determine the amount of effort needed to push or pull the wagon up the walkway. Students should come to realize that a change in force makes a substantial difference in movement. Ask the students whether or not there are forces on

- an object that is standing still (e.g., halfway up the ramp)
- an object that is moving

Supporting Educational Research: Benchmarks: pp. 89, 94
Related Science Standards: 1, 2, 4, 5, 9
Related Workplace Readiness Standards: 3.3, 3.9, 3.10, 4.2, 5.4

Moving Toys. Each student brings in a moving toy from home. Working in groups, the students analyze how each toy moves.

- Does it have wheels?
- Do some of its parts move?
- Where does the energy for the toy's movements come from?
- How are the toy's movements similar to how people move?

Students discuss the toy's movements and develop a short oral/visual presentation explaining how their toy moves.

After these presentations are made, draw the students' attention to the different ways the toys move. Some are wind-up toys, some need batteries, and some are operated by hand.

Next, students design and make their own moving toys using plastic drinking straws, brass fasteners, cardboard, and other everyday materials. Challenge them to make their devices move up and down as well as from side to side without directly touching the toy. For example, a balloon fastened over the top of a plastic soda bottle will inflate and make the toy move when the bottle is squeezed.

Supporting Educational Research: Benchmarks: pp. 89, 94
Related Science Standards: 1, 2, 4, 5, 9
Related Workplace Readiness Standards: 3.3, 3.9, 3.10, 4.2, 5.4

The Force of Wind. The push or pull of the wind is often difficult for students to see in the same way that they can see other forces acting. The following two activities are designed to show that the wind's force is real and measurable.

Students create a wind-powered pulley by following these steps:

- First, they place a thread spool onto a pencil axle.
- They design fan blades and fasten them onto the spool.
- Then they tie one end of a piece of thread to a paper clip and fasten the other end of the thread to the spool so that the thread winds up as the spool turns.
- Students point a hair dryer at the fan blades to make the spool turn, thus winding up the paper clip. (They will need to standardize the distance of the hair dryer from the blades. Advise them to use the coolest temperature setting possible).

Ask students to predict the blade design and the hair dryer blower speed that will make the spool turn to lift up the paper clip in the shortest time. They can set up experiments to test these predictions.

Students figure out the best parachute design that will keep five pennies (or whatever weight they choose) in the air for the longest period of time.

Supporting Educational Research: Benchmarks: pp. 89, 94
Related Science Standards: 1, 2, 4, 5, 9
Related Workplace Readiness Standards: 3.3, 3.9, 3.10, 4.2, 5.4

Indicator 3: Recognize that some forces are invisible and can act at a distance.

LEARNING ACTIVITIES: Grades K-2

Magnet on Toy Car. Students place a magnet on a small plastic car. When they bring another strong magnet near the car, the car should move—even though the two are not touching. Challenge the students to predict what will happen if they bring the different poles of magnets near each other. As they set up assorted experiments, they describe what they think is happening. Is the force going through the air? Confirm their correct explanations and correct their misconceptions.

Paper Clip on Thread. After tying a thread onto a paper clip, have students hold a magnet in the air near the clip. The clip will rise into the air. After students make some predictions, they place thin objects between the clip and the magnet. They try to answer questions such as the following:

- What materials seem to affect the force?
- What is the effect of the distance between the clip and the magnet on the ability of the magnet to hold the clip in the air?

Magnetic vs. Nonmagnetic Classification. Students classify objects as *magnetic or nonmagnetic*. Ask them what characteristics the magnetic objects appear to have in common. (Be sure to include enough samples of each type.)

Supporting Educational Research: Benchmarks: p. 94
Related Science Standards: 2, 4, 5, 9
Related Workplace Readiness Standards: 3.6, 3.10

LEARNING ACTIVITIES: Grades 3-4

Demonstrating Magnetic Fields. Put a bar magnet under a transparency sheet on an overhead projector, and sprinkle iron filings on the sheet. Place various poles together to create different patterns as the iron filings arrange themselves along the lines of force in the fields. Explain the term field as needed.

Students can do a similar activity, working carefully with the iron filings. One way of keeping the filings from getting all over is to place them in Petri dishes and tape the dishes closed. However, the container may be hard to use with normal bar magnets. Cylindrical magnets are smaller and may be more appropriate for this activity.

To show that a magnetic field is three-dimensional, carefully place a cow magnet into a test tube that is secured inside a larger jar containing many iron filings. (Cow magnets are magnets fed to cows to attract any pieces of metal the cow eats so the metal does not harm the cow.) Gently shake the jar. The iron filings will attach themselves to the test tube, showing that something is clearly all around the magnet. Students will also be interested in why cow magnets are given to cows and their impact on the farming industry.

Magnetized Needle. Float a large magnetized needle on a small piece of cork in water. The needle always moves in a certain direction. Have students note its direction. Compare with a compass needle.

Supporting Educational Research: Benchmarks: p. 94
Related Science Standards: 2, 4, 5, 9
Related Workplace Readiness Standards: 1.3, 2.6, 3.7, 3.15

Static Electric Fields. Students design and conduct different static electricity experiments. They can easily create a charge by rubbing a strip of transparency sheet with plastic "cling" wrap. After repeating this action with a second strip of transparency sheet, they bring the two identically charged materials together. What happens? Next, students create two other charges by rubbing strips of transparency sheets with wool. What happens when these two strips are brought together?

Finally, students bring the transparency strip rubbed with plastic wrap near a piece of transparency sheet rubbed with wool. What happens? Students compare and contrast all these actions with magnetic fields.

Gravitational Fields. Have students hold a book or other unbreakable object about one foot above the floor and predict what will happen if they let it go. What if the object is dropped from a stepladder? What if it is dropped from a second-floor window? Is there some height at which their predictions would change? Discuss what is causing the effect, and explain that the effect continues even when the object hits the ground. Students will begin to see that gravity is more than just the weight of an object on the surface of the Earth and will begin to understand the nature of gravitational fields.

Supporting Educational Research: Benchmarks: p. 94
Related Science Standards: 2, 4, 5, 9
Related Workplace Readiness Standards: 1.3, 2.6, 3.7, 3.15

Building Electromagnets. Students build an electromagnet and discover that there is a force in the electromagnet that repels or is attracted to a magnet. Students identify the factors that can determine the amount of movement. They show that the electromagnet can pick up things that were not touched in the beginning. (*Caution:* Only touch wires to a battery momentarily; otherwise, wires will get *hot*. Be sure to follow appropriate safety precautions.)

The class can hold a contest to design the best electromagnet. In small groups, students list all the factors they think may affect the strength of electromagnets and then test each one to find the best design for each factor. They combine all the best designs into the electromagnet they will use in the contest to pick up the greatest number of paper clips.

Compass Investigation. Students investigate how a compass reacts to weak and strong magnets. Each student balances a bar magnet hanging on a thread. In what direction do all the bar magnets seem to point? What does this suggest? (*Note*: It may be necessary to move students apart from each other so the individual magnets do not affect each other.)

Falling Objects. Students discover which shapes allow objects to fall faster than other shapes. They design experiments in which the weight of objects is kept constant, but the shape is changed. Next, they use another set of objects in which the shape is the same but the weight varies.

Supporting Educational Research: Benchmarks: p. 94
Related Science Standards: 2, 4, 5, 9
Related Workplace Readiness Standards: 3.15, 4.5, 5.4

Indicator 4: Investigate sources of heat and show how heat can be transferred from one place to another.

LEARNING ACTIVITIES: Grades K-2

Fluids in Motion. Students set up various types of convection experiments to simulate ocean movement, air currents, and other fluid motions. (Remind them to use normal safety procedures regarding goggles.)

- They place a drop of food coloring in one end of a container of water being heated by something hot. What happens?
- They place open baby-food jars of very warm water, cold water, and room-temperature water into an aquarium of tap water at room temperature. What happens?
- They place drops of food coloring in very warm water and also in cold water. What differences occur in the motion?

Heat Lamp. Turn on a heat lamp at least 10 feet away from students. Students predict and then time how long it takes for the heat to reach them. Can they detect the heat in the back of the room?

Take a cookie sheet or a piece of cardboard covered with aluminum foil and bend it into a curved mirror. Students discover they can bounce the lamp's heat rays off the cookie sheet or foil-covered cardboard. They can investigate what type of surface absorbs or reflects the most heat. Encourage students to see similarities with how sound moves. (*Note*: The differences between sound and light will not be apparent with these experiments.)

Supporting Educational Research: Benchmarks: pp. 83-84
Related Science Standards: 2, 4, 5, 9
Related Workplace Readiness Standards: 3.6, 3.9, 5.7

How Animals Keep Warm. What do animals do that helps them stay warm? In the following activities, students study the features that protect animals from the cold.

- Students put some vegetable shortening or lard (to represent the fat on an animal's body) on a finger, which they then place in cold water. As a control, they put another finger in cold water and compare the amount of cold each finger feels.
- Students place a finger in a balloon partially filled with air. This balloon represents an animal's oily surface, which keeps water from its skin. They immerse the finger in cold water and compare how this finger feels in cold water with another finger also in cold water.
- Students wrap a finger with cotton to simulate a fur-bearing animal's protection from extreme temperature. They place that finger in ice and then in ice water. They compare and contrast what happens to this finger with what happens to an unprotected finger.

Discuss with the students how they keep warm. Include in your discussion mention of the following:

- layering
- type of material
- color (dark vs. light)
- function of hats and gloves

Challenge students to determine how many layers of newspaper are required to keep a small jar of ice from melting for one hour and for the whole school day.

Supporting Educational Research: Benchmarks: pp. 83-84
Related Science Standards: 2, 4, 5, 9
Related Workplace Readiness Standards: 3.6, 3.9, 5.7

LEARNING ACTIVITIES: Grades 3-4

Air Currents. Using thin pieces of tissue paper, students look for air currents in their classroom. Suggest that they check by the bottoms of doors and near windows. Have a big pot of warm water and another big pot of cold water in the classroom. Using the movement of tissue paper as an indicator, students determine in what direction the air is moving around the pots. Discuss the implications of what they discovered.

Chemical Sources of Heat. In this activity, students discover that some chemical reactions produce heat. Wearing goggles and following appropriate safety precautions, they place a small amount of calcium chloride (road salt) pellets in a cup. They carefully place the cup into a sealable plastic bag containing some water and then close the bag. Students carefully mix the items and notice the amount of heat that is produced. Demonstrate commercially sold cold and hot packs to the students as examples of a practical application.

Supporting Educational Research: Benchmarks: pp. 83-84
Related Science Standards: 2, 4, 5, 9

Partner Convection Experiments. In groups of two, students fill a baby-food jar with cold water and place a laminated index card over the jar. Holding the card on top of the jar, one of the students of each pair turns the jar over. The card will stay on the jar.

The partner fills another jar of the same size with cold water. Since this is a bottom jar, the jar must be filled to the very top. The student adds some food coloring to the water in the jar.

Working in a deep plastic tray, the students place the first jar precisely on top of the bottom jar and then slide out the laminated card. They observe what happens, determining the movement of the water by watching what happens to food coloring. Does the water move? (*Note*: The bottom jars must be totally full or students will see motion caused by the water dropping, not by any other cause.) The student partners repeat the procedure with various combinations of water, e.g., hot over hot, warm over warm, hot over cold, and cold over hot.

Students keep records of their observations. At some point, they should be able to explain the patterns of movement and answer questions such as the following:

- When does the most movement occur? The least movement?
- What does this suggest about movement of water in the oceans or ponds or even in a sink?
- What happens if salt water is used?

Discuss sources of heat with the students and demonstrate some (such as the following) with student participation.

- Rub hands together (heat by friction).
- Use a hot plate (heat due to electrical resistance).
- Bend a coat hanger back and forth (also showing heat due to friction).
- Light a match (following safety requirements regarding goggles and fire extinguisher).

Supporting Educational Research: Benchmarks: pp. 83-84
Related Science Standards: 2, 4, 5, 9

Indicator 5: Investigate sources of light and show how light behaves when it strikes different objects.

LEARNING ACTIVITIES: Grades K-2

Light Mystery Box. Set up a mystery box with only a dime-size hole in it. Place brightly colored pieces of paper inside. What colors do students see? Ask the students to compare the way the papers look inside the box with the way they look outside the box.

Different Color Lightbulbs. Students look at various objects in normal room lighting, noticing their color. Darken the classroom and shine lightbulbs of different colors (one at a time) on the objects. Ask students to describe what seems to happen to the color of objects as lightbulbs of different colors illuminate the objects.

Totally Dark Room. In a totally dark room hold up a piece of paper and ask students to describe what color paper it is. They will not be able to tell. Next, use a very dim light. The students will see objects, but no color. Discuss how humans see things.

Seeing Through Rose-Colored Glasses. In this activity, have students wear goggles covered with two pieces of red cellophane. Place toothpicks of different colors on the floor. Ask the students to pick up toothpicks of any color except green. After one or two minutes, they count how many non-green toothpicks they picked up. Discuss why green toothpicks appear black when viewed with red-covered goggles. The fact that many animals cannot see all colors can lead to an interesting classroom discussion.

Mirror Cards. Have students play "mirror cards" in which a mirror is used to complete a drawing. For example, if students have half a butterfly, how would they use a mirror to show the whole image? If they have three triangles arranged in a pattern, how could they use a mirror to reverse the image? The designs can range from beginner to very advanced, in which students use two or more mirrors to create the final drawing.

Supporting Educational Research: Benchmarks: pp. 83-84
Related Science Standards: 2, 4, 5, 9
Related Workplace Readiness Standards: 3.3, 3.7

Light Striking Various Surfaces. Students allow a light to go through or strike a variety of flat and curved surfaces. What do they notice happening to the light? For example, if students shine a light on flat mirrors and flat glass, what happens?

Heating of Materials by Sunlight. Allow sunlight or a properly protected lamp to shine on the following items and determine which becomes warmer.

- Set 1: Bowls of water with different colors of paper under the bowls
- Set 2: Bowls of colored water
- Set 3: Different color sands
- Set 4: Soils of different texture

Students observe and discuss what seems to be happening.

What happens to the light coming from the sun when it reaches the Earth? Use a globe to enhance the discussion.

Supporting Educational Research: Benchmarks: pp. 83-84
Related Science Standards: 2, 4, 5, 9
Related Workplace Readiness Standards: 3.3, 3.7

LEARNING ACTIVITIES: Grades 3-4

Water Drop Experiments. Working cooperatively in small groups, students attempt to figure out what size and shape of a water drop magnifies an image the most. They use an eyedropper to place drops of water on waxed paper over newsprint. Students look at a side view of each drop to see the shape of the drop. They relate the shape and size of the drop to its magnification.

Light Beams. Pass a thin beam of light through a piece of diffraction grating or prism. (A specially made slide with a thin slit works well in a slide projector to produce a thin beam of light.) A spectrum should appear on the wall or a piece of paper depending on position. Ask students which conditions result in the clearest spectrum or the thickest spectrum. When is a spectrum not visible? Discuss where the colors of the spectrum come from.

Students position a piece of diffraction grating or prism at one end of a tube. When they hold the tube up to a classroom light, they will see the spectrum. Further investigations could be to examine bulbs of different colors. Are there differences? *Caution:* Students should avoid looking directly at the sun or at sunlight reflected in a mirror.

Next, students can investigate what parts of the spectrum become visible when lightbulbs of different colors are used.

Colored Goggles. Students make goggles from the plastic rings that are used to hold a six-pack of soda cans together. They can make two sets from each six-pack. For lenses, they fasten various colors of cellophane (one color at a time) onto the goggles. Working with a partner, they view a set of at least five pieces of paper of different colors. Students record their findings and compare how each color of paper looked when viewed through each color of lens. Ask the students questions such as the following:

- Which lens made which color is the brightest?
- Did any color seem not to be affected by the color of the lens?

Supporting Educational Research: Benchmarks: pp. 83-84
Related Science Standards: 2, 4, 5, 9
Related Workplace Readiness Standards: 3.3, 3.7, 4.2

Convex and Concave Mirrors. Students can create convex or concave mirrors in one of two ways:

- They carefully place shiny aluminum foil on the inside or outside of large bowls.
- They bend disposable cookie sheets to form the mirrors. If they use cookie sheets to form concave mirrors, they will be a ble to bend the sheet to focus the light at various locations.

Next, students shine light on these convex or concave mirrors and describe what happens.

Convex and Concave Lenses. Have students collect lenses from old eyeglasses, magnifying glasses, etc. How do objects appear when viewed through the different lenses? Do all lenses have the same shape? Are they all made of the same material? Have students make their own lens by filling a clear glass jar with water or another clear liquid. A discussion of why some people need eyeglasses could include an explanation of the lenses in the human eye.

Supporting Educational Research: Benchmarks: pp. 83-84
Related Science Standards: 2, 4, 5, 9
Related Workplace Readiness Standards: 3.3, 3.7, 4.2

Indicator 6: Demonstrate how sound can be produced by vibrating objects and how the pitch of the sound depends on the rate of vibration.

LEARNING ACTIVITIES: Grades K-2

Rubbing a Comb. Students rub a comb over an edge. As they increase the speed at which the teeth hit the edge, the pitch goes up.

Feeling Vibrations. In the following activities, students have the opportunity to feel vibrations.

- Place objects inside coffee cans with lids. As students shake the cans, they hear the difference in the sounds of various objects and feel the vibrations.
- Students hold their hand on their vocal cords and feel the vibrations as they talk.
- Students hold their hand on a speaker of a stereo system. They note the difference in vibration as the speaker reacts to changes in volume and pitch of the music.

Making Musical Instruments. Working in groups, students brainstorm as many sounds as possible. Why do these things make noise? Discuss the nature of sound, introducing the concept of vibration.

Demonstrate (or ask students to demonstrate) how a variety of instruments are played. Include examples of percussion, reed, and stringed instruments. As a class, discuss how the instruments are designed. Encourage students to design their own instruments using a variety of recycled materials. (Teacher-made examples would be useful.) If time permits, students can tune some of the string and percussion instruments (e.g., glass jars filled with water) to specific notes and play some simple, familiar songs.

Supporting Educational Research: *Benchmarks,* p. 89
Related Science Standards: 2, 4, 5, 9
Related Workplace Readiness Standards: 1.3, 3.2

LEARNING ACTIVITIES: Grades 3-4

Seeing Sound Vibrations. Cut off both ends of a can. Cover one end of the can with a tightly stretched balloon. Glue a small, lightweight mirror or a flat piece of shiny aluminum foil to the middle of the outside of the balloon. Shine a light onto the shiny surface, which will make a spot of light on the wall or ceiling. Students make sounds into the open end of the can to discover the effect on the pinpoint of light on the wall or ceiling. What happens to the movement of this light spot as they make sounds of different pitches or loudness?

Seeing Sound Waves. This activity enables students to "see" sound waves. Set up an oscilloscope with a microphone. Because each pitch produces a different wave, it will be relatively easy to identify students through their unique wave patterns of the same sound. Each pitch can be given a number. The music teacher can loan or demonstrate tuning forks, all of which have a number indicating their vibrations per second. Frequently, local research firms will be glad to send in an older oscilloscope and someone to demonstrate its use in making sound visible.

Videodiscs are available showing short clips on pitch; time-lapse pictures of vibrating objects, including the vocal cords; and pictures of sound waves on oscilloscopes.

Supporting Educational Research: *Benchmarks,* p. 89
Related Science Standards: 2, 4, 5, 9
Related Workplace Readiness Standards: 2.7, 3.4, 4?

Making or Transmitting Sound. Set up a series of tasks for small groups of students to complete. Sample tasks include the following:

- Determine what thickness, tension, and length of rubber bands give the highest pitch.
- Set up bottles with different levels of water, and play a tune by blowing into each bottle.
- Build a string telephone that works.
- Determine what materials make the clearest string telephone that can carry sound over 20 ft.
- Design a string telephone that will work around a corner.

Students complete each activity at their own speed, checking their procedures and conclusion with the teacher. Each student is then held accountable for being able to demonstrate and explain what was done to solve the problem.

Supporting Educational Research: *Benchmarks,* p. 89
Related Science Standards: 2, 4, 5, 9
Related Workplace Readiness Standards: 2.7, 3.4, 4

Indicator 7: Demonstrate how electricity can be used to produce heat, light, and sound.

LEARNING ACTIVITIES: Grades K-2

Speaker and Sound. Any speaker will show that an electrical flow can produce sound. As students hold their hand on a speaker, they feel a difference as the volume changes and as the pitch changes.

Producing Heat with Electricity. Toasters and lightbulbs obviously give off heat. (In fact, almost anything electrical produces heat.) Students can feel the heat and measure the rise in temperature by bringing a thermometer near each device. (Be sure to follow all appropriate safety procedures!)

Supporting Educational Research: *Benchmarks*, p. 89
Related Science Standards: 2, 4, 5, 9
Related Workplace Readiness Standards: 5.1, 5.4

LEARNING ACTIVITIES: Grades 3-4

Nichrome™ Wire Experiments. Students set up experiments with #32 Nichrome wire in a simple circuit with a light bulb to discover how the wire affects the brightness of the lightbulb. They determine the effects of increasing the length of the Nichrome wire and its diameter (just wrap more wire together) on the brightness of the bulbs. A thin piece of aluminum foil will get hot enough to melt if placed in the circuit without the lightbulb. The Nichrome wire will also get hot under certain conditions, so caution students in its use. Discuss how bad or improperly installed wiring in homes or other buildings is a potential cause of fires. Invite a city/town building inspector to address these issues.

Simple Circuit. Students investigate simple circuits using several lightbulbs and one battery. Next, they study the differences between what happens to the bulbs when they are wired in series and when they are wired in parallel. Students can also determine the effect of placing batteries in series (only one or two—more than two will probably burn out the bulbs) or in parallel (any number of batteries will be fine).

An electrician could be invited to discuss with the class how homes are wired, why switches are used, and so on.

Buzzers. Student groups may be able to construct buzzers using wire, nails, a block of wood, pieces of metal, and a battery. After figuring out how to control the pitch and loudness of the sound produced, they apply this knowledge to create a Jeopardy™ game or game board.

Supporting Educational Research: *Benchmarks*, p. 89
Related Science Standards: 2, 4, 5, 9
Related Workplace Readiness Standards: 1.3, 5.6

Indicator 8: Explain how a moving object that is not being subjected to a net force will move in a straight line at a steady speed.

LEARNING ACTIVITIES: Grades 5-6

Toy Car. How far will a toy car roll? Using a variety of toy cars, students experiment to see how far they can get a car to roll. They attempt to answer questions such as the following:

- Can the car roll forever? Why not?
- What are the forces acting on the rolling car?
- What would happen if the force of friction could be totally eliminated?

Some students who may already have experienced designing cars for "derby" competitions should be a valuable resource.

Related Science Standards: 2, 5

LEARNING ACTIVITIES: Grades 7-8

Inertia. In order to learn about inertia, students compare the factors at work in a system of inclined planes and sudden stops. Student groups construct inclined planes of various heights on which they release a toy car. On each toy car, students place a clay person that moves with the car. At the bottom of the ramp, they place a broad straightaway with a structure low enough to stop only the car.

Students attempt several trials at each height and determine the average "flying" distance for the clay person. They graph the car's data (distance and time) and compute the speed of the car for each attempt.

Changing the surface of the straightaway and/or the inclined plane could be used as a follow-up lesson on potential energy and friction.

Related Science Standards: 1, 2, 4, 5

Indicator 9: Show that when more than one force acts on an object at the same time, the forces can reinforce or cancel each other, producing a net force that will change the speed or direction of the object.

LEARNING ACTIVITIES: Grades 5-6

Tripod Pendulums. Working in groups, the students construct freestanding (tripod) pendulums with a small magnet as a bob. They swing the pendulum and trace its path in pencil as it swings. At the bottom of the tripod, the students place several small magnets, one at a time, near the pendulum's path. They observe any change in the path. Students move the magnets and predict the new path, explaining what force(s) will change the path.

Related Science Standards: 2, 4, 5

Modes of Transportation. Students bring in toys or models that represent different modes of transportation on land, on water, and in the sky. They group the toys by method of movement and then examine each type:

- Land transportation—Students examine their models and use them to sketch diagrams. They draw arrows to show the forces acting on each vehicle when it is (a) moving along a level highway, (b) going uphill, (c) going downhill, and (d) parked.
- Water transportation—Similarly, students diagram the forces acting on boats. Different means of propulsion (paddles, oars, sails, etc.) as well as the effect of water currents add to the challenge of the task.
- Air transportation—Students once again analyze the forces acting on airplanes, balloons, helicopters, etc. as they explore the dynamics of flight. A discussion and demonstration of how an airplane changes direction should be part of this activity.

Related Science Standards: 1-5

Forces on an Airplane. A paper airplane contest is ideal for an introduction to a forces discussion.

First students construct identical paper airplanes and compare throwing forces and techniques. Then they create airplanes of different designs and hold an "open" contest, in which they vary the airplanes' path, speed, distance, and hang time.

Fluid Pressure. The forces exerted by fluids must often be considered when studying all of the forces acting on an object. Students can easily demonstrate the idea of moving-fluid pressure by using paper-airplane wings and/or Ping-Pong(balls.

- Students construct an airplane wing of paper and blow above, below, and directly at the wing to determine the best design and angle.
- Students place a Ping-Pong ball in a beaker (or cup) and blow over the beaker. They then measure the height of the ball as it moves upward in the beaker.

Related Science Standards: 1, 2, 4

LEARNING ACTIVITIES: Grades 7-8

Car Loop. Students construct a loop using plastic track. They propel toy cars on the track by rolling them, using an inclined plane, and/or using a spring-loaded propulsion device. After several practice shots, the students collect data on the following:

- mass of the car
- height of the incline
- distance traveled
- time needed for the journey.

Using the data collected, students determine the average speed, minimum speed, and minimum incline needed to propel the car through the loop. They attempt to answer questions such as the following:

- What factors or forces altered the car's journey?
- Why did some cars fail to complete the loop?
- Which cars were successful most often and why?

Have students demonstrate other objects that move in a circle. Discuss the force(s) that keep things moving in circles, such as the planets moving around the sun.

Related Science Standards: 1, 2, 4, 5, 11

Simple Machines. Students investigate the concepts of force, fulcrum, and resistance by first researching how humans have used simple machines throughout history.

Small groups of students cooperatively construct a simple machine such as an inclined plane, pulley, or lever. Using their machine, the students perform a specific task such as moving a bookcase, lifting a desk, or pushing a chair. After all the groups test their simple machines, they make a presentation to the entire class.

Related Science Standards: 1, 2, 4, 5

Indicator 10: Investigate how the force of friction acts to retard motion.

LEARNING ACTIVITIES: Grades 5-6

Overcoming Friction. Students pull a flat-bottomed mass across various surfaces, using a spring scale to measure the force required to overcome friction. Students collect data on the distance, time, and force required for each surface and then graph this data. They predict the force needed to move a given object over a specific surface.

At this point, student groups could design an object/surface combination that provides the easiest journey. Next, the student groups list possible ways to reduce the friction (e.g., sand, water, ball bearings, grease or other lubricants). They then design an experiment, graphing the data generated. They compare the graph to determine the best lubricant for this type of movement.

Related Science Standards: 1, 2, 4, 5

Parachute Car. Students use a toy jet car with parachute deceleration to demonstrate air resistance on a moving object. They launch the car and measure distance, time, and surface material. The students graph the time vs. distance for each vehicle to determine the fastest machine and best deceleration. How does the parachute work to slow the car down?

Related Science Standards: 1- 5

LEARNING ACTIVITIES: Grades 7-8

Surface Friction. Once again, model cars are used to investigate the effect of force on the motion of an object. Using a ramp to produce a constant starting speed, students allow a car to roll onto different surfaces and record the "stopping distance" caused by each surface. Surfaces are then listed in order of resistance, and students attempt to explain the force of friction in terms of texture, composition, etc.

Related Science Standards: 1, 2, 5

Indicator 11: Describe the various forms of energy, including heat, light, sound, chemical, nuclear, mechanical, and electrical energy, and how that energy can be transformed from one form to another.

LEARNING ACTIVITIES: Grades 5-6

Energy and Communications Technology. The development of communications technology provides the opportunity for an array of activities that demonstrate energy transfer.

Historical Perspective. Using the Internet or print resources, students research the important telecommunication inventions of the last 300 years and make a time line. They answer questions such as the following:

- Did people from different countries work on similar inventions at the same time?
- What scientific and/or technological principles were incorporated into each device?
- Was the device something completely new, or did it build upon a previous invention?
- What were the societal demands that promoted their development?
- How did our society change as a result of the new technologies?

Electricity Basics. In groups of two, the students work with a series of progressively more complex circuits using DC buzzers to communicate a message. The simplest circuit is comprised of a DC buzzer that is turned on and off by a switch and powered by a battery. The final circuit has two switches and two buzzers, with each switch activating both buzzers. Students diagram each circuit schematically and explain them to the class. Their explanation should identify all the different forms of energy at work in their system—electrical, sound, mechanical, etc.

Other Energy Forms. An extension activity could allow students to design and add more-sophisticated components involving other forms of energy such as light or chemical.

Supporting Educational Research: *Benchmarks*, pp. 81- 86, 193, 199, 293;
Hutchinson, J. & Karsnitz, J. 1994. *Design and problem solving in technology*. Albany, NY: Delmar Publishers, Inc., p. 5.
Related Science Standards: 1-4

LEARNING ACTIVITIES: Grades 5-6

Lewis Latimer. African-American engineer Lewis Howard Latimer developed the process used for manufacturing carbon filaments for the Thomas A. Edison lightbulb. The filament (the very fine, threadlike material in a lightbulb) glows whenever electricity passes through it. A major technological advancement, Latimer's work on the filament made electric lightbulbs safe and inexpensive for ordinary households.

The following activities simulate situations that Lewis Latimer and other workers at the Edison Company might have encountered.

- Students sketch a picture of a flashlight bulb and label the *wire* and the *filament*. They identify the parts of the bulb that are associated with Latimer's investigations.
- Students fold a 30.5 cm (1 ft) by 1.3 cm (1/2 in.) strip of aluminum foil in half and connect one end of it to the negative pole of a 6-volt lantern battery. They tightly wrap the other end around the threads of a flashlight bulb. (They must be sure that the foil does not touch the metal on the bottom of the bulb.) Students carefully form an electric circuit by holding the bulb so that the bottom part of the bulb touches the positive pole of the battery. They explain what is happening in their own words. They investigate what happens if they rearrange the parts of the circuit or add a second bulb.
- Students pour two tablespoons of salt into a saucer and add water to just below the rim. They cut another piece of folded aluminum foil (the same size as they used before) in half. They connect one piece to the negative pole of the battery and connect the other foil strip to the positive pole. Then they hold the battery so that the two strips of foil are in the water. (Caution them not to let the strips touch each other.) Ask the students to explain what happens.

Supporting Educational Research: Higginson, Linda. 1996. "Selling an Energy Source." *Science Scope*, 19(5), Feb. Madrazo, Gerry. 1993. *Multiculturalism in Mathematics, Science and Technology: Readings and Activities.* Addison-Wesley, pp. 103-106.
Related Science Standards: 1, 4
Related Workplace Readiness Standards: 2.1, 2.2, 2.9, 3.1, 3.3, 4.1, 4.11, 5.1, 5.4, 5.9

- Students fold a 91 cm (3 ft) by 5 cm (2 in) piece of aluminum foil lengthwise three times. They wrap the folded foil strip around a nail in coils, leaving about eight inches of foil free on each end. They then connect each end of the foil strip to one of the poles on the battery. Touch the nail to a paper clip. Explain what happens.
- An electric current produces effects that are thermal, chemical, and magnetic. Latimer used an electric current to make his incandescent lamp work. Ask students to explain which effects Latimer would be most concerned about in the design of the lightbulb.
- Students compare the design of lightbulbs used today and determine which design is most efficient and cost-effective.

LEARNING ACTIVITIES: Grades 7-8

Energy Transfer. In a safe section of the school grounds, students ride bicycles as they identify and explain the types of energy being produced and transferred. For example,

A green plant transformed *solar energy* into *chemical energy*.

Students bodies transformed the chemical energy obtained from food into the heat necessary to maintain their bodies' temperature as well as the *mechanical energy* necessary to move the bike's pedals.

The bike's pedals turn the wheels in an illustration of mechanical energy.

When students apply the brakes, the brake pads rub against the wheels, creating the *friction* needed to slow or stop the bicycle. Any accompanying screeching sound involves *sound energy*. The friction may result in the formation of heat.

Related Science Standards: 1, 2, 4

Mall Physics. For many students, a mall is a popular meeting place. It is also an excellent place to study energy and its transfer. Send the students to the mall with directions to make observations of motion, reflections, and other energy phenomena. Back in the classroom, students discuss their findings and convert their observations to questions. They work in teams to design experiments that they could do to answer these questions. They then return to the mall to investigate these questions.

Possible locations and activities include the following:

- Electric organ store - Students try identical notes separately on two different organs and compare sounds, beats, and musical intervals.
- Elevator/escalator - Students determine average speed and apparent weight changes. When on an elevator they compare the readings on a scale when the elevator is stopped and when it is moving up or down. As an extension they could determine its acceleration and deceleration. While on an escalator, they determine its length and its relative speed when loaded and unloaded.
- Fountain - Students estimate the water flow.
- Mall/store lighting - Students use diffraction gratings to observe and compare spectra of various lighting sources in the mall.
- Energy use - Students make an order-of-magnitude estimate of the amount of electrical energy used to light the entire mall at night and then estimate the cost to light the mall.

- Stairs/human work - Students calculate the number of times they would have to climb the stairs in order to "burn" the energy stored in a food item that can be purchased at the mall. (Assume 100% efficiency of the body and no changes in kinetic energy). As an extension, students compare their own power output while walking up the stairs with their output while running up the stairs.
- Store mirrors - Students observe the images formed in different types of mirrors they find in the mall (e.g., convex observation mirrors, concave makeup mirrors, and multiple clothing store mirrors).
- Windows - Students analyze the glare reflected off a variety of surfaces by orienting Polaroid sunglasses in multiple positions.
- Encourage students to find other examples of physical science in the mall and report on these. They can make comparisons between malls.

Supporting Educational Research: "Shopping Mall Physics", *Science Teacher*, March 1996, p. 37.
Related Science Standards: 1, 2, 4, 5

LEARNING ACTIVITIES: Grades 7-8

Power Plant Role-Play. In this simulation activity, the class pretends that New Jersey is planning to build a new power plant that will supply electricity to an area. Student groups assume the role of various development firms, each trying to promote a particular energy source (e.g., solar, wind, oil, natural gas, coal, tidal, hydroelectric, geothermal, nuclear biomass, garbage incineration). Each student group researches information about their energy source such as

- where it can be found
- how it is obtained and/or processed

The students develop a media presentation to try to sway the voters. The presentation should include the following points:

- advantages and disadvantages of this type of power plant
- the environmental impact
- where this type of plant currently exists
- costs
- diagrams, charts, and graphs supporting the energy source

After the class vote, students hold a meeting to review the success of their presentations.

Supporting Educational Research: Higginson, Linda. 1996. "Selling an Energy Source." *Science Scope*, 19(5), Feb. Madrazo, Gerry. 1993. *Multiculturalism in Mathematics, Science and Technology: Readings and Activities*. Addison-Wesley, pp. 103-106.
Related Science Standards: 1-5
Related Workplace Readiness Standards: 2.1-2.10, 3.1-3.5

Indicator 12: Explain how heat flows through materials or across space from warmer objects to cooler ones until both objects are at the same temperature.

LEARNING ACTIVITIES: Grades 5-6

Heat Transfer. In the following activities, students investigate different aspects of heat transfer.

Present the class with the following situation. Suppose a student wants to make soup for lunch and finds the microwave is broken. What type of pot will heat the soup the quickest? Challenge students to design experiments to compare different types of pots (e.g., aluminum, stainless steel, glass, porcelain) and pot bottoms (e.g., copper).

Students investigate the best methods of keeping their lunch hot or cold. They research how a thermos or an insulated bag works. They then design experiments to show how these work.

Related Science Standards: 1-6, 8, 11
Related Workplace Readiness Standards:
1.1, 2.1-2.9, 3.1-3.15, 4.1-4.11, 5.1, 5.2, 5.4, 5.5-5.9

LEARNING ACTIVITIES: Grades 7-8

Energy Efficiency. In this activity, students will investigate the energy efficiency of different types of houses. They investigate various building materials and how they relate to energy efficiency.

In small groups, students collect and analyze energy efficiency data and determine the relationship of certain variables to the energy efficiency of houses. These variables may include

- color and material of the roof
- the amount of insulation
- the direction the house faces
- the number of exposed windows
- the landscape

Power companies regularly perform energy audits and offer a variety of free energy education resources for schools. Invite a power company representative to speak to the class about energy audits and their typical recommendations to homeowners to improve the energy efficiency of a home. Students can then conduct an energy audit of their own homes and compare with their classmates.

Supporting Educational Research: Campbell, Melvin D. 1990. “Hot or Cold.” *Science Scope*, NSTA, Jan.
Related Science Standards: 1-5, 10
Related Workplace Readiness Standards: 1.1-1.3, 1.5, 1.7, 1.9, 2.1-2.10, 3.1-3.15, 4.1-4.11, 5.1, 5.4-5.6, 5.8

Freezing Water. For the longest time, a controversy has existed over which freezes faster, hot or cold water. Students survey 10 people of different ages and discuss the results with the class. They form their own hypothesis and design an experiment to test their hypothesis. Review these designs for safety considerations. Students then perform the experiment at home or in class and discuss the results.

As an extension activity, students calculate the amount of energy needed to freeze the water from the starting temperature.

Supporting Educational Research: Campbell, Melvin D. 1990. "Hot or Cold." *Science Scope*, NSTA, Jan.
Related Science Standards: 1-5, 10, 16
Related Workplace Readiness Standards: 1.1-1.3, 1.5, 1.7, 1.9, 2.1-2.10, 3.1-3.15, 4.1-4.11, 5.1, 5.4-5.6, 5.8

Indicator 13: Explain that the sun is a major source of the earth's energy and that energy is emitted in various forms, including visible light, infrared, and ultraviolet radiation.

LEARNING ACTIVITIES: Grades 5-6

Solar Energy. In this activity, students attempt to discover the best location for siting a garden on the school grounds, based on the availability of solar energy. After learning about solar radiation, they work in groups to design a device that will measure solar energy. Their devices should involve variables such as container type, color, and material to get an approximate measure of the sun's energy, which can be used to compare one location with another. Do the different devices agree on the best location for the garden?

Supporting Educational Research: Sorge, Carmen. 1995. "Capturing the Sun's Energy." *Science Scope*, 18 (8), May.
Related Science Standards: 1-2, 4-7, 10
Related Workplace Readiness Standards: 1.1-1.3, 1.5, 1.7, 1.9, 2.1, 2.2, 2.8, 2.9, 3.1, 3.3, 3.6-3.15, 4.1-4.11, 5.4, 5.5, 5.8

LEARNING ACTIVITIES: Grades 5-6

The Greenhouse Effect. Much of the sun's energy (*solar radiation*) becomes trapped in the atmosphere as *heat*. (Some solar radiation initially is absorbed by the Earth's surface; some is reradiated into the atmosphere but cannot pass out of the atmosphere.) Students can better understand this concept in the following simple activity. They shine a light on two thermometers: one that is enclosed in a stoppered test tube and another that is suspended in air. They compare the temperatures. Like the Earth's atmosphere, glass around the thermometer can trap heat energy. The light rays heat up the air in the tube, which cannot move around as much as the air around the suspended thermometer can.

As an extension activity, a greenhouse works on the same principle. If the glass walls of a greenhouse were covered with black material, it would make the room much hotter. However, because plants need light, glass or another transparent material is needed. Students can investigate the materials that greenhouses are made of and how the temperature and amount of sunlight are regulated. They can build cardboard models or just cover a box with plastic, then design experiments to investigate conditions inside the greenhouse.

Related Science Standards: 1-5, 12
Related Workplace Readiness Standards: 1.1, 2.1-2.10, 3.1-3.15, 4.1-4.11, 5.4, 5.5-5.9

LEARNING ACTIVITIES: Grades 7-8

Energy Technology. This activity focuses on the importance of using energy wisely and preserving energy resources, by asking questions such as the following:

- How have different people and cultures used energy in the past?
- What are the various forms of energy and how are they measured?
- What are the differences between renewable and nonrenewable energy sources?
- What is the energy policy of the United States?
- How is energy converted and utilized to benefit society?
- What could be designed to utilize a renewable energy source in the school, community, or home?

These questions raise issues of scientific fact and provide opportunities for application through technological design and problem solving.

Students conduct an energy audit in which they list (on a spreadsheet) how they use energy (what type of energy and for what purpose) over a 24-hour period. Examples will include energy necessary for the heating/cooling of their environment, transportation, food preparation, personal care, entertainment, and the production of anything they used during the observation period. Next, the students evaluate the degree to which renewable versus nonrenewable energy sources were used and evaluate the environmental impact of each identified energy use. Students interview a person from a previous generation to determine how energy use has changed.

Supporting Educational Research: *Benchmarks,* p. 194
Related Science Standards: 1-4, 9

Energy Conservation. Students brainstorm ideas for reducing their dependence on nonrenewable energy sources (e.g., use less, conserve, or change to a renewable source). Selecting from the best brainstorming ideas, students will engage in technology by designing and making/modeling items for an improved energy utilization in their school, home, or community.

For example, they can

- design solar heaters or ovens
- reduce air infiltration
- plan for carpooling
- suggest a sweater/sweatshirt day and lower building temperatures
- develop a system to reduce unnecessary lighting
- design new line of clothing
- develop a system that automatically turns off lighting in unoccupied rooms

Supporting Educational Research: *Benchmarks,* p. 194
Related Science Standards: 1-4, 9

Receiving Wavelengths. Challenge students to investigate this statement: "In general, the longer the wavelength of electromagnetic radiation, the larger the detector must be." Students name some common detectors and explain how their size relates to the wavelength they detect. They explain how antennas; (short wave, radio, and television) work in regard to channel numbers. As an extension activity students find out whether the eyes of small insects are sensitive to ultraviolet waves or infrared waves.

When radio waves enter a tunnel (or other long, narrow region) radiation with wavelengths much longer than the width of the tunnel are absorbed more than radiation with smaller wavelengths. Ask students if they would expect AM or FM car radios to fade out more when traveling through tunnels. What about using other devices such as car phones? Students make a model to show what happens to waves in a tunnel.

Related Science Standards: 1-5, 11
Related Workplace Readiness Standards: 1.1, 2.1-2.10, 3.1-3.15, 4.1-4.11, 5.5, 5.8

Indicator 14: Show how light is reflected, refracted, or absorbed when it interacts with matter and how colors appear as a result of this interaction.

LEARNING ACTIVITIES: Grades 5-6

Periscope. Students construct a periscope to look around corners and over objects using paper-towel cardboard tubes and small mirrors. To determine the angles for the mirrors in the periscope, they set up mirrors on tables and use a flashlight to see how light is reflected. Students draw up blueprints and construct their periscopes. They compare the devices to find the best design.

Related Science Standards: 2, 4, 5

Mirrors. In the following two activities, students work with mirrors to study the reflection of light.

- Students determine where to place a mirror (or mirrors) in their room for optimum reflection depending on their height. They also help their parents place mirrors in the bedrooms of the younger children in the family.
- Students design a curved mirror for a fun house to make them small, large, wide, or narrow.

Related Science Standards: 2, 4, 5
Related Workplace Readiness Standards: 1.1, 2.2, 3.1-3.15, 4.1-4.11, 5.1-5.3, 5.5-5.9

LEARNING ACTIVITIES: Grades 7-8

Lenses. Humans often use lenses or benefit from lenses in their everyday lives, many times without realizing it. Prescription eyeglasses and contact lenses, magnifying glasses, microscopes, telescopes, and kaleidoscopes all utilize lenses. Lenses have helped us to see microscopic organisms, thus giving us the understanding necessary to conquer disease. In this activity, students investigate how one of these items work and try to duplicate it by using different lenses. For example, they may build an astronomical telescope to understand how a combination of different lenses operate. As an extension students investigate how lenses are used in the eye, how they are used to correct vision defects, and how cataracts affect vision.

Underwater. Students measure the angle of refraction between a straw (or pencil) and different liquids in a glass. They use this data to explain how different types of mirages are produced. Students relate this to seeing other submerged objects, such as fish in a lake.

Related Science Standards: 1-6, 11, 12
Related Workplace Readiness Standards: 1.1-1.2, 1.5, 2.1, 2.2, 2.5, 2.6, 2.9, 3.1-3.15, 4.1-4.11, 5.7

Indicator 15: Show how vibrations in materials can generate waves which can transfer energy from one place to another.

LEARNING ACTIVITIES: Grades 5-6

Sound Travel through Solids. Sound waves can be transmitted in solids, liquids, and gases by compression waves. In order to illustrate the transmission of sound waves in solids, students construct string telephones. Each group of students uses a different type of material for the string (e.g., cotton, twine, plastic, or wire); all use a plastic mouthpiece and ear pieces. Using a predetermined sentence, phone each group and have them copy the message. Students graph the results (the number of words heard correctly vs. the number of words in the entire message). They can use the results to determine the most accurate string "phone." This activity can initiate a class discussion concerning the history of communication from drum beating to cellular devices.

Sound Travel through a Liquid. Students illustrate the motion of sound waves through water by clicking rocks or using a metallic clicker out of water and under water and comparing the quality of the sound and source.

Related Science Standards: 1-5

Sound Travel through a Gas. To illustrate sound travel in air, students construct a series of 8 to 10 puffed-cereal pendulums suspended from a coat hanger. Then they pluck a stretched rubber band near (but not touching) a pendulum. As the sound waves reach the pendulum, the next pendulum will move and the others will follow.

Students collect data on the distance each pendulum swings. They can vary the distance of the stretched rubber band from the first pendulum and/or vary the intensity of the pluck.

If a tree falls in a forest and no one is there, does it make a sound? This statement could be the focus of a debate in the class or between student groups.

Related Science Standards: 2, 5

LEARNING ACTIVITIES: Grades 7-8

Straw Oboes. Students construct a straw oboe (one per student) making small V-shaped notches (6-8) along a plastic straw at 1.5-cm intervals. They pinch the end of the straw together. The students then blow gently into their straw, opening and closing the notches to change the pitch of the sound. Students with some background in music may be able to identify the note and/or reproduce it with an instrument of their own. A class discussion about the history of wind instruments can follow.

Straw Pipes. Students cut plastic straws into sections to produce musical notes. They construct single pipes for each note, using an entire straw as well as the following fractional cuts: 1/4, 1/2, 8/15, 3/5, 2/3, 3/4, 4/5, and 8/9 of a straw. Each group member will play one or two pipes as the group play a tune for the class.

Related Science Standards: 2, 5
Related Workplace Readiness Standards: 5.3, 5.4

Indicator 16: Explain the mathematical relationship between the mass of an object, the unbalanced force exerted on it, and the resulting acceleration.

LEARNING ACTIVITIES: Grades 9-12

Newton's First Law of Motion. Provide groups of students with a set of four or five identical-looking, labeled boxes that differ greatly in mass by simple multiples, e.g., empty, 1 unit, 2 units, 3 units, 4 units, more than 4 or 5. (Use packing material so that any objects put in the boxes to supply mass don't move around.) Students work cooperatively to experiment with the boxes by pushing or pulling them around on the same surface. They answer questions such as the following:

- Which box is the easiest to move?
- Which is the most difficult?
- How far does each move when given a similar shove?
- How can a similar force be produced consistently?
- How does each box move on a ramp?

After experimentation, the students rank the boxes in order of mass. Next, challenge the student groups to find the mass of each box relative to the others, e.g., the mass of each in terms of the box with the least or most mass. Does the relative mass of each box explain the ease with which it was moved in the first part of the experiment?

Each group uses the results of their experimentation and plans a presentation to the class that includes their answers to the following questions:

- What ranking does the group have for the boxes based upon mass?
- What are the masses of the boxes relative to each other?
- What is the relationship of these masses to the movement of the boxes in the first investigation?

Supporting Educational Research: *National Science Education Standards*. 1996. p. 177.
Related Science Standards: 2, 5, 9
Related Workplace Readiness Standards: 2.2, 2.7, 2.9, 3.1, 3.3, 3.6, 3.10, 3.12, 3.15, 4.2-4.5, 4.9, 5.4, 5.7

Newton's Second Law of Motion. Students propel a dynamics cart with one unit of force, such as one large rubber band, and measure the time required to travel a fixed distance. They double and triple the units of force acting on the cart and then record the time it takes to travel that same distance. Since acceleration is the rate of change in velocity, the students view the decreasing time as increasing acceleration. They compute the changing acceleration ($d = ½\ at\ 2$, $a = 2d/t2$). They can then graph the acceleration as a function of the changing force, thus verifying the direct relationship between the acceleration and the unbalanced force.

Students also explore the relationship between the acceleration and the mass of an object when the unbalanced force remains constant. They use a fixed amount of force, such as one large rubber band, and measure the time it takes the dynamics cart to travel a fixed distance. They double and triple the original mass and detect the increasing time (and therefore the decreasing acceleration). To show the inverse relationship, they calculate the acceleration and graph it as a function of the changing mass. They can also graph acceleration as a function of the reciprocal of the mass values to show this relationship. Spreadsheet or graphing programs can improve their curve-fitting and make the analysis easier and more interesting.

Supporting Educational Research: *National Science Education Standards*. 1996. p. 177.
Related Science Standard: 5
Related Workplace Readiness Standards: 2.8-2.10, 3.12-3.15

Indicator 17: Prove that whenever one object exerts a force on another, an equal amount of force is exerted back on the first object.

LEARNING ACTIVITIES: Grades 9-12

Newton's Third Law of Motion. Pairs of students experiment on free-rolling chairs by pushing off of each other's feet or tugging on a rope between them. Trials should vary to include students of similar mass as well as students whose masses vary greatly. The students record the speed and distance traveled by each student. They note whether a given student (or pair of students) travels the same distance each time. They brainstorm ways to standardize the push/tug.

The class records observed and measured data and uses this data to answer questions such as the following:

- Is it possible for one of the objects to experience a larger or smaller force than the other?
- If the forces are the same magnitude, why do the students move at different speeds and to different distances?

Supporting Educational Research: *National Science Education Standards.* 1996. p. 177.
Related Science Standards: 1, 2, 5, 9
Related Workplace Readiness Standards: 3.1-3.3, 3.6, 3.7, 3.9, 3.12, 4.2, 4.9, 5.3, 5.4, 5.7

Next, students of different masses push off of a wall. Other students record the speed and distance traveled by each student. They note whether a given student travels the same distance each time. They brainstorm ways to standardize the push. The class uses this data to answer questions such as the following:

- If the forces are the same, why do the students move at different speeds and to different distances?
- What is the relationship between the student's mass, the speed, and distance? The class designs an experiment to test their ideas about mass, force, and motion. The goal is to collect and graph data to illustrate the relationships between these quantities.

Two variations of the above activity are listed below:

- Students carry out similar experiments with objects of various mass attached by a spring on an air table, air track, or some other low-friction surface. They use the spring to push or pull the objects from rest.

- Students fill a plastic or reinforced glass bottle with a mixture of baking soda and vinegar and then lightly stopper it. They lay the bottle on it's side on a low-friction surface or on rollers. (Caution: The reaction builds up gas under pressure!) When the stopper is expelled from the bottle, the momentum of the system is conserved. Students predict the relative distance the stopper and bottle will move based upon their mass and the law of conservation of momentum.

Supporting Educational Research: *National Science Education Standards*. 1996. p. 177.
Related Science Standards: 1, 2, 5, 9
Related Workplace Readiness Standards: 3.1-3.3, 3.6, 3.7, 3.9, 3.12, 4.2, 4.9, 5.3, 5.4, 5.7

Indicator 18: Know that gravity is a universal form of attraction between masses that depends on the masses and the distance between them.

LEARNING ACTIVITIES: Grades 9-12

Gravity and Distance. Drop an object and ask students why the object fell. They should respond that gravitational force caused the object to fall. Next, drop a larger object of the same composition to demonstrate that a larger gravitational force exists between the Earth and a more massive object. The more massive object does not fall faster or slower than the less massive object, yet it can produce more impact when it hits. A spring balance can be used to measure the gravitational force (weight) between each object and the Earth.

It is more difficult for students to understand the inverse square law of gravitational force and distance. Demonstrate this important concept with light (since an experiment with gravity is difficult to conduct). Light intensity changes inversely to the square of the distance from the source. Use this phenomenon as an analogy for the way gravitational force changes.

To illustrate this concept geometrically, draw one point representing a light source with a rectangular area at one distance unit and a second rectangular area at two distance units. The second rectangle must be drawn so that four straight lines originating from the light source point are connected to all four vertices of both rectangles. It should become clear that the area of the rectangle at two distance units is four times greater than the area of the rectangle at one distance unit, demonstrating that the area increases as the square of the distance from the light source. This means that the intensity of the light at two distance units, covering four times greater area, is only a quarter of the intensity that exists at one distance unit. This will help students relate this concept to gravitation and infer the same inverse relationship for gravitational force and distance.

Supporting Educational Research: National Science Education Standards, p. 177.
Related Science Standards: 2, 9
Related Workplace Readiness Standards: 3.1- 3.3

Indicator 19: Know that electrically charged bodies can attract or repel each other with a force that depends on the size and nature of the charges and the distance between them.

LEARNING ACTIVITIES: Grades 9-12

Electrostatics. Working individually or in small groups, students explore electrostatics with a variety of materials (e.g., simple electroscopes, suspended glass and hard-rubber rods, plastic combs, balloons and bits of paper). Students can charge these materials by rubbing them with wool, hair, or silk. They discover answers to the following questions:

- Does the number of strokes with the charging material affect the strength of the charge?
- Which materials produce charges that attract each other?
- Which produce charges that repel?
- How can the strength of the charge be represented?
- Does the wool, hair, or silk become charged as well as the object rubbed?

In a full-class setting, gather data from the students and use demonstrations to illustrate each important principle. A Van de Graaf generator is a dramatic tool for demonstrations of electrostatics. Other suggested demonstrations include the following:

- Give suspended balloons like or opposite charges and move them closer or further apart to show the relationship between *distance* and *force*.
- Deflect a thin stream of water from a tap with a charged object.
- Suspend or support a large beam of wood on a low-friction pivot and attract it with a charged object.

When there is some humidity, rub a large piece of plastic (PVC) pipe with fur or wool to create a very strong charge. (The other demos work best in low humidity.)

Supporting Educational Research: *Hands-On Physics Activities*, pp. 290-292.
National Science Education Standards, p. 177.
Related Science Standards: 2, 9
Related Workplace Readiness Standards: 2.2, 3.2, 3.7, 3.9, 3.11, 3.12, 4.3, 5.4-5.7

Electrostatics (continued). As extension activities, students cut out paper figures and make them "dance" by attracting them with charged objects. They can investigate how large the figures can be and still be moved with a certain charge.

To illustrate concepts of electrostatics, initiate a class discussion of electrical safety with questions like the following:

- Why are electrical safety devices made out of the materials they are?
- What are safe behaviors in a lightning storm?
- How are home electronics shielded against static electricity?

Supporting Educational Research: *Hands-On Physics Activities,* pp. 290-292.
National Science Education Standards, p. 177.
Related Science Standards: 2, 9
Related Workplace Readiness Standards: 2.2, 3.2, 3.7, 3.9, 3.11, 3.12, 4.3, 5.4-5.7

Indicator 20: Explain the similarities and differences between gravitational forces and electrical forces that act at a distance.

LEARNING ACTIVITIES: Grades 9-12

Gravitational and Electrostatic Forces. In groups, students review their understanding of gravitation and electrostatics. They research answers to the following questions:

- What are some examples in which the electrostatic force is greater than the gravitational?
- What are some examples in which the gravitational force is greater than the electrostatic force?
- What are the visual similarities and differences between the two basic equations - Newton's Law of Universal Gravitation and Coulomb's Law?
- Are there distance limits for these two forces?

The groups report their findings back to the class.

Challenge student groups to compare the electrostatic force and the gravitational force mathematically. Assign each group a pair of objects that will repel electrically and attract gravitationally (e.g., two electrons, two protons, two helium nuclei, or any two simple ions with the same charge). With the help of a spreadsheet program, the students use Coulomb's Law and Newton's Law of Universal Gravitation to compare the forces. They attempt to answer questions such as the following:

- Which force is the stronger force?
- How much stronger is one force than the other?
- What do these findings explain about the way these forces work in everyday life?

Supporting Educational Research: *National Science Education Standards*, p. 177.
Related Science Standards: 3, 9
Related Workplace Readiness Standards: 3.1, 3.2, 4.2, 4.9

Gravitational and Electrostatic Forces (continued). Extensions and variations of the above activity include the following:

- Students investigate the role electrical and gravitational forces play in the lives of stars. What is the relationship between gravitational and electrical forces in a normal star, a red giant, a neutron star, or a supernova? Each of these situations is determined by which fundamental force "wins."
- Students write compare/contrast essays or use a Venn diagram to show the similarities and differences between gravitational and electrical forces.
- Students trace the history of the scientific ideas (and the people who developed them) that led to both Newton's Law of Universal Gravitation and Coulomb's Law.

Supporting Educational Research: *National Science Education Standards*, p. 177.
Related Science Standards: 3, 9
Related Workplace Readiness Standards: 3.1, 3.2, 4.2, 4.9

Indicator 21: Know that the forces that hold the nucleus of an atom together are stronger than electromagnetic forces and that significant amounts of energy are released during nuclear changes.

LEARNING ACTIVITIES: Grades 9-12

Nuclear Physics. Students research the ways that the discoveries of nuclear physics have affected their lives and the lives of people they know. Examples include radiation treatments for cancer, diagnostic tools in medicine, and electricity generated by a nuclear power plant. In teams, students debate the issues regarding the use of nuclear power.

Students make comparisons between the following:

- electromagnetic forces (Coulomb's Equation) and Einstein's theory of mass-energy transfer involving the speed of light
- the kinds of potential energy, such as electromagnetic (solar) energy and nuclear energy
- the forces that hold the electrons to the nucleus

In their study of nuclear reactions, students can use a Geiger counter, a nuclear scaler, or a cloud chamber with a source of alpha and beta emissions. A sealed beta source can be used to expose Polaroid film. Half-life as well as chain reactions can be demonstrated in many ways. Instructors should also discuss terms such as *binding energy* and *mass defect*. An important area in which to engage students is a debate on nuclear power and on researching thermonuclear reactions (fusion). Simulated protocols on the stability of nuclei are readily available and appropriate for this unit.

Supporting Educational Research: *Science Teacher,* Oct. 1992, March 1992, Jan. 1989
Chem Sources. ACS. Vol. 3, pp. 4-31.
Related Science Standards: 1, 3-5
Related Workplace Readiness Standards: 2.5

Indicator 22: Explain how electromagnetic waves are generated and identify the components of the electromagnetic spectrum.

LEARNING ACTIVITIES: Grades 9-12

X Rays. Students compare the effects of X rays on bone, aluminum, and lead. They investigate historical uses of X rays, the amount of X rays a person may have during the year, and new technology that has taken the place of X rays. Students visit with technicians and doctors at local hospitals to learn about the new diagnostic techniques such as *magnetic resonance imaging (MRI)*. They report their findings to the class.

Related Science Standards: 1- 5, 8, 12
Related Workplace Readiness Standards: 1.1, 1.5, 1.7, 2.1-2.10, 3.1-3.15, 4.1, 5.5, 5.6, 5.8

Color. Students investigate the visible range of the electromagnetic spectrum. They try to answer questions such as:

- What determines color?
- Why are some things colored and others not?

They relate the colors of the spectrum to the frequency of light waves.

Students use a spectrophotometer and various filters (e.g., red, blue-green, and yellow) to determine complementary colors and study other examples of transmittance or absorbance. They learn that color arises through the preferential absorption of a fraction of the white light (*electromagnetic radiation*) falling on an object.

Supporting Educational Research: Chem 13 News. 1972-75.
Related Science Standards: 2, 3, 8, 9
Related Workplace Readiness Standards: 1, 5

Uses of Electromagnetic Radiation. Students know about a variety of waves, such as radio and TV waves, microwaves, X rays, gamma rays, infrared waves, and ultraviolet waves. Many of these waves are considered to have potentially dangerous side effects. For example, students see signs in hospitals warning that microwaves are in use. Their parents tell them not to sit too close to the television. They hear that tanning salons are not good for them. X-ray technicians step out of the room when they perform an X ray. They hear people discussing irradiated food.

In this activity, students research the components of the electromagnetic spectrum and make a display of the different types of waves, showing the relative length of each. They also compare the uses of each of these waves as well as safety concerns.

Related Science Standards: 1-5, 11, 12
Related Workplace Readiness Standards: 1.1, 1.3, 1.5, 1.7, 1.9, 2.1-2.10, 3.1-3.5, 4.1-4.11

EMFs. The safety of electromagnetic fields (EMFs) is a controversial topic that has been in the news and has presented a dilemma to scientists and power companies alike. To date, the question remains open as to the harm that strong EMFs pose to living things. A related effect is the impact of strong sources of EMF on the value of nearby real estate.

In teams, students research possible topics such as the following:

- an overview of electromagnetic fields
- EMF research
- epidemiology and EMF
- regulation and EMF
- public reactions to EMF
- media coverage of EMF issues
- the electromagnetic spectrum

Next, students collect data near sources of EMF (e.g., TV set, microwave, stereo, computer). They use a gauss meter to measure the EMF strength at varying distances around each electrical appliance and a graphing calculator to collect and analyze the data. They use their findings to build a mathematical model of the EMF around each device.

Supporting Educational Research: *National Science Education Standards*, p. 177.
Related Science Standards: 2, 5, 12
Related Workplace Readiness Standards: 2, 3, 4

Indicator 23: Explain that all energy is either kinetic or potential and that the total energy of the universe is constant.

LEARNING ACTIVITIES: Grades 9-12

Toys and Energy. Individually or in groups, students work with toys that store energy (e.g., spring-popping toys, jumping discs, wind-up toys, rubber-band toys, battery-operated toys). They address a series of questions:

- What example of kinetic energy did you observe?
- How is the energy stored in this toy (potential energy)?
- At what point is this toy moving fastest (greatest kinetic energy)?

The students record their observations and measurements on a data sheet. They write an explanation of how each toy stores and uses energy, describing the form of energy and the manner in which it is transferred. By comparing the amount of work done on the toy and the work done by the toy the students can calculate the efficiency of the energy transfer.

Several variations of this activity are listed below:

- Students work in groups to investigate an assigned toy, which they demonstrate and explain to the class. The class evaluates their presentation.
- Students write compare/contrast essays or use a Venn diagram to show the similarities and differences between two toys.
- Students design—or design and actually build—a new toy that uses a simple form of energy storage such as a rubber band or a spring.

Supporting Educational Research: *Teaching Science with Toys.* 1994. Middletown, Ohio: Terrific Science Press, pp.187-195
National Science Education Standards, p. 177.
Related Science Standards: 2, 5, 9
Related Workplace Readiness Standards: 2.7, 2.9, 3.2, 3.7, 3.9, 3.11, 3.12, 4.2, 4.3, 4.5, 4.9, 5.4, 5.7

Bouncing Balls. Working in groups, students drop different types of balls to see how high they will rebound. They do research, make observations, and design experiments to answer the following questions:

- When does the ball have potential energy?
- When does the ball have kinetic energy?
- Why doesn't the ball return to the original height?
- What happens to the energy of the ball that is "lost" each time it bounces?

Students can use electronic tools to measure the motion of the objects. The groups share and discuss their findings with the entire class, which then compares the results and forms general conclusions.

Several variations of this activity are listed below.

- Students see how high a squash ball will rebound after it is dropped from a height of one meter. They then place the ball in a hot-water bath (about *60*°C) and repeat the one meter drop. What is different about the kinetic energy of the ball at room temperature and the heated ball? How long does this difference last? (Caution the students to take appropriate safety precautions with the hot water bath.)
- Students use kinematics equations to predict the speed that the balls will have just before they strike the floor. They design a method to measure the speed in order to check their calculations. Students use the difference in height (and potential energy) to calculate the efficiency of the bounce.
- Students experiment with a Ping-Pong™ (ball, a golf ball, a basketball, and a Superball™). Drop the balls individually and stacked (touching) in various combinations on a hard surface. It may take a few moments of practice to get the desired effect. What causes the "blast-off" effect that is observed with the stacked balls? Which combination will produce the greatest height?

Supporting Educational Research: *National Science Education Standards*, p. 177.
Related Science Standards: 2, 9
Related Workplace Readiness Standards: 3.1- 3.3

Heat Exchange. Ask the class these two fundamental questions in thermodynamics:

- Which way does the heat energy flow, from the hot to the cold or from the cold to the hot?
- Is the energy conserved?

In cooperative learning groups, students design their own experiments to test their hypotheses. For example, they may create two separate systems of thermal energy, one with hot water and the other with cold water. They would then connect the two systems with a metallic conductor to allow the heat energy to exchange between two systems and attach a thermometer or heat probe to each system. They may even attempt to create a "closed system" that encloses both the hot and cold reservoirs of energy. Advise the students to insulate the thermal system to minimize the heat loss. Encourage them to make any necessary assumptions about the conservation of energy. Evaluate the students' design, and suggest how they can improve their experimentation.

Students then conduct their experiments and collect data. They use a spreadsheet program to organize and analyze their data. They compute the heat energy lost and gained, generate a mathematical equation that models the heat exchange between the hot and cold systems, and predict how long it will take for the two systems to reach an "ideal" equilibrium state (or the same temperature) and how long it will take to reach the final state.

In a written laboratory report, the students present their hypotheses, data, analysis of data, computational work, conclusions, and ideas for further investigation. Encourage the students not only to present their answers to the questions but also to evaluate the strengths and weaknesses of their claims, arguments, and data.

Related Science Standard: 5
Related Workplace Readiness Standards: 2.7-2.9, 3.6-3.12

SCIENCE STANDARD 10

All students will gain an understanding of the structure, dynamics, and geophysical systems of the earth.

INTRODUCTION

This standard provides students with the skills and understanding needed to interpret their geophysical surroundings, explaining the origin and composition of the planet on which they live and the weather systems generated by a dynamic atmosphere.

They relate the nature of the Earth's crust to surface features that are readily observable. The geography and geology of New Jersey and the rest of the world is explained in terms of tectonic processes, mountain building, water erosion, glaciation, and changes in ocean level as learners acquire and use investigative skills to identify the effects of such processes anywhere on the globe.

The dynamic interrelationship between the ongoing changes in the planet's surface, its oceans, and its atmosphere is linked to a study of the Earth's climate and weather, including discussions of the impact of weather on human activities.

DEVELOPMENTAL OVERVIEW

In grades K-4, young children need a feel for their surroundings. By studying familiar locations, drawing maps, and experimenting with different types of maps, children become more fully aware of their neighborhoods and then their state, nation, and world. Such experimentation introduces students to symbolic representation and models.

Children need to understand where the materials in their world come from. In age-appropriate fashion, children are introduced to characteristics for identification and separation that can be applied to rocks and minerals. The existence and probable origin of various fossils are introduced as students observe and describe fossils of many different life-forms.

Using the concepts of properties and classification, students in the primary grades begin to observe water and its importance on the surface of the Earth. Because students are affected by weather, they are naturally interested in keeping and examining their own records of weather conditions.

By grades 5-8, the middle school years, students learn to create and use more types of maps, including a variety of map projections. For students in the middle grades, the study of the Earth sciences can introduce processes as well as long-term and large-scale changes. The study of weather becomes systematic and predictive. Earth science facts are related, and systems involving many components are introduced.

By grades 9-12, students develop abstract thinking skills, and more complex Earth science processes are introduced to help students explain their environment and the features of the Earth and its atmosphere. Students are expected to relate movements of the Earth's crust to observed surface features. Their understandings and interpretation of the socioeconomic impact of weather should draw upon the relationships among surface waters, oceans, atmospheric conditions, and weather phenomena.

DESCRIPTIVE STATEMENT

The study of science should include a study of the planet Earth and its relationship to the rest of the universe. This standard describes what students should know about the composition of the Earth and the forces that shape it, while *Science Standard 11* describes what students should know about astronomy and space science.

CUMULATIVE PROGRESS INDICATORS

By the end of Grade 4, students

1. Recognize and demonstrate the use of different kinds of maps.
2. Investigate materials that make up the Earth, including rocks, minerals, soils, and fossils, and how they are formed.
3. Identify major sources and uses of water, discussing the forms in which it appears.
4. Collect and record weather data to identify existing weather conditions, and recognize how those conditions affect our daily lives.

Building upon knowledge and skills gained in the preceding grades, by the end of Grade 8, students

5. Compare different map projections, and explain how physical features are represented on each.
6. Identify the major features of the Earth's crust, the processes and events that change them, and the impact of those changes on people.
7. Identify the age of fossils, and explain how they provide evidence that life has changed through time.
8. Describe and explain the causes of the natural processes and events that shaped the Earth's surface and interior.
9. Monitor local weather conditions and changes in the atmosphere that lead to weather systems.
10. Investigate the composition, cycling, and distribution of the world's oceans and other naturally occurring sources of water.

Building upon knowledge and skills gained in the preceding grades, by the end of Grade 12, students

11. Use the evidence provided by topography, fossils, rock stratification, ice cores, and radiometric data to investigate the earth's changes.

12. Use the theory of plate tectonics to explain the relationship among earthquakes, volcanoes, mid-ocean ridges, and deep sea trenches.

13. Explore how weather phenomena and human activity are interrelated.

14. Identify and explain factors that influence water quality needed to sustain life.

LIST OF LEARNING ACTIVITIES FOR STANDARD 10

GRADES K-4

Indicator 1:

GRADES K-2
Maps as Representations of Real Things
Map Scavenger Hunts!
Representing Shapes on Maps

GRADES 3-4
Edible Map
Computer Map (Inedible)
New Jersey Road Map
Kinds of Maps

Indicator 2:

GRADES K-2
Rocks and "Nonrocks"
Breaking Rocks

GRADES 3-4
Fossil Imprints
Making Sandstone
Sorting Beach Objects
Rocks for Sale!
Classifying Minerals
Growing Crystals
Observing Soil

Indicator 3:

GRADES K-2
Water-Cycle Plays
Forms of Water
Family Water Use

Condensation
Earth, a Water Planet

Indicator 4:

GRADES K-2
Day-to-Day Weather

GRADES 3-4
Weather Station
Daily Weather Journals

GRADES 5-8

Indicator 5:

GRADES 5-6
Map Projections
Map Cutouts

GRADES 7-8
3-D Topographic Map

Indicator 6:

GRADES 5-6
Hallway Mural
Sands from around the World

GRADES 7-8
Coastline Maps and Models
Historic Maps
Rate and Time

Indicator 7:

GRADES 5-6
Fossils over Time

GRADES 7-8
Correlation of Rocks via Fossils
Decay Simulation
Fossils and Sedimentation Estimates

Indicator 8:

GRADES 5-6
Earthquake Model

GRADES 7-8
Volcanism and Diastrophism
Finding the Epicenter

Indicator 9:

GRADES 5-6
Weather Journal
Dew and Frost
Internet Weather

GRADES 7-8
Weather Forecasting
An Approaching Low

Indicator 10:

GRADES 5-6
Density Currents
Upwelling and Downwelling

GRADES 7-8
Ocean Surface Currents
Seawater Composition

GRADES 9-12

Indicator 11:

Ice Bubbles
Stratigraphy
Sedimentation

Indicator 12:

Plate Puzzle
Plate Edges

Indicator 13:

Snow Removal
Hurricanes and Major Storms

Indicator 14:

Water Quality
Nonpoint Source Pollution

Indicator 1: Recognize and demonstrate the use of different kinds of maps.

LEARNING ACTIVITIES: Grades K-2

Maps as Representations of Real Things. This activity helps students understand that maps are symbolic representations of real things. Students first explore and carefully study their classroom. Then, using blocks, cartons, cardboard, or any appropriate material, they build a three-dimensional model of the room. Next, they create a two-dimensional map of their model to represent the real objects by drawing symbols on the map. Students can use this same process to create maps of their playground or school, a city block, or their neighborhood.

Related Science Standards: 2, 5
Related Workplace Readiness Standards: 2.8, 3.1, 3.2, 3.15, 4.2, 5.3, 5.7, 5.8

Map Scavenger Hunts! To prepare for this activity, hide some objects in the classroom (or playground), and create a map that includes locations of the hidden objects. Using these maps, students look for the objects in pairs or small groups.

Later, students hide some objects themselves and create a new map with the locations of these objects marked. They challenge their partner or another group to search for the hidden objects using the new map.

Related Science Standards: 2, 4
Related Workplace Readiness Standards: 2.9, 3.9, 3.15, 4.2, 4.9, 5.4, 5.7

Representing Shapes on Maps. Students observe large objects in the classroom, such as desks, tables, and other pieces of furniture. Students associate shape with the surfaces of the objects. For example, a desk may have a rectangular top surface or a square side, while a tabletop might be round. Cut these surfaces out of sponges. Student groups, each working with a large sheet of paper that represents the classroom floor, then put the sponge shapes in the correct places on their classroom "map." The classroom objects can be moved, and the students can then modify their maps. Students can make their maps permanent by dipping the shaped sponges in washable paint and printing these shapes on the map.

Related Science Standards: 2, 4
Related Workplace Readiness Standards: 2.9, 3.9, 3.15, 4.2, 4.9, 5.4, 5.7

LEARNING ACTIVITIES: Grades 3-4

Edible Map. In this activity, students create an edible map of the state of New Jersey. Using baked pizza dough or plain sheet cake, student groups first create the basic shape of New Jersey. Using toppings such as colored icing, sprinkles, or small vegetable pieces, students represent the state's geographical and political features, including mountains, rivers, lakes, cities, towns, highways, and the state capitol.

Computer Map (Inedible). Students can use computer software to make maps of their bedroom, their route to school, a shopping mall, or a local store. Students exchange their community maps and write stories or directions using these maps.

Related Science Standards: 2, 5
Related Workplace Readiness Standards: 1.2,1.7, 2.8, 3.1,3.9,3.15,4.2,4.10

New Jersey Road Map. Student groups each receive a large road map of New Jersey. The students first trace familiar routes to historic landmarks, shopping malls, vacation destinations, etc. The students then look for the roads to geographical and geological features such as

- roads through a water gap
- roads paralleling mountain ridges
- roads winding alongside a meandering river

Students compare the location and direction of these roads to that of the natural feature. They create models or diagrams illustrating the correlation between human activity and natural surface features. Encourage students to relate their discoveries in journal entries, written reports with actual photographs, or computer multimedia presentations.

Related Science Standards: 2, 5
Related Workplace Readiness Standards: 1.2, 1.7, 2.8, 3.1, 3.9, 3.15, 4.2, 4.10

Kinds of Maps. Through this activity, students become aware that maps have specific purposes and uses. From newspapers, magazines, CD-ROMs, or the Internet, the students collect many different kinds of maps, including as the following:

- road maps
- weather maps
- political maps
- star maps
- hiking maps

Students study how these maps are used by interviewing people using specific maps, noticing how people use maps, or by using the maps themselves. Next, they create their own specialized map and ask a partner to use it. For example, one person can make a map of classmates' neighborhoods. Then that student can ask the partner to find his/her own house on the map.

Related Science Standards: 2, 5
Related Workplace Readiness Standards: 1.2, 1.7, 2.8, 3.1, 3.9, 3.15, 4.2, 4.10

Indicator 2: Investigate materials that make up the earth, including rocks, minerals, soils, and fossils, and how they are formed.

LEARNING ACTIVITIES: Grades K2

Rocks and "Nonrocks." In this activity, students discover some differences between rocks and "nonrocks" displayed around the classroom.

- The *rocks* are typical of specimens found throughout New Jersey and should have very obvious characteristics.
- The *nonrocks* should be equally obvious (e.g., bricks, cinder blocks, and sidewalk pieces).

Students compare and classify the objects as rocks or nonrocks. Students then choose their favorite rock and examine it closely for touch, feel, color, etc. A magnifying glass or hand lens can provide a closer look. Ask the children to choose words to describe the rocks, and write them on the chalkboard. Encourage students to describe where they think their rock was found.

Related Science Standards: 1, 2, 5
Related Workplace Readiness Standards: 2.8, 3.1, 3.3, 3.8, 3.9, 4.2, 5.1, 5.4, 5.7

Breaking Rocks. Students discover that some rocks can be broken apart. In this exercise, student groups receive plastic jars with lids, rock samples, squares of white cloth, and a container of water. (Be sure that at least one type of rock breaks easily.) Students place small pieces of rock into each jar, add some water to cover the rocks, and put on the lid. The students should designate one jar as a "control" and leave it unshaken. They should shake all the other jars hard for awhile. This shaking simulates rocks tumbling in a stream or rocks being pounded by waves at a shoreline. After shaking the jars, the students remove each lid and replace it with a cloth square fastened with a rubber band. Then they pour off the water used in the shaking. As the students examine rocks and the cloth, they try to answer the following questions:

- How have the rocks changed?
- Is there anything on the cloth surfaces?
- If so, where did the material come from?
- How do the surfaces of the cloths compare to that of the control?

Related Science Standards: 1, 2, 5
Related Workplace Readiness Standards: 2.8, 3.1, 3.3, 3.7, 3.12,3.13, 4.2, 5.4, 5.5, 5.7

LEARNING ACTIVITIES: Grades 34

Fossil Imprints. Students simulate how evidence of past life (*fossils*) was retained in rocks. They first examine real fossils, especially those that are imprints into rock. Students next collect shells, leaves, and other objects and press them into soft clay or wet plaster of Paris, leaving marks and imprints. Leaves can even be left behind. Using watercolors, students can paint the resulting “fossiliferous sedimentary rock” (if plaster of Paris is used) to make the simulations look real.

Making Sandstone. How do some rocks form? In this activity, students simulate the creation of *sandstone*, a type of sedimentary rock. Students pour a supersaturated salt solution into a small paper cup that contains some sand—and then set the cup aside. Students record their daily observations in journal entries. When the ingredients in the cup are completely dry, students can peel the paper away to reveal sand grains cemented together in newly formed “sandstone.”

Related Science Standards: 1, 2, 5
Related Workplace Readiness Standards: 3.1, 3.3, 3.7, 3.12, 3.13, 4.2, 5.4, 5.5, 5.7

Sorting Beach Objects. Students receive a bucket containing sand and objects typically found on a beach. Using simple sieves (or their hands), they sift out the objects from the sand. The students then classify their beach objects by sorting them into groups based on similar properties, e.g., size, color, composition, and origin (natural vs. synthetic). Then ask them to sort their beach objects again, but in a different way.

If they haven't yet done so, ask the students to sort their beach objects into two groups: LIVING (or a shell, exoskeleton, or egg case produced by a living thing) or NONLIVING. They continue by sorting the NONLIVING category into groups until they have a group of rocks. They sort the rocks by their properties (e.g., color, texture, appearance, size, and shape). Finally, they draw pictures of the rocks in their classified groups and label the groups using the property by which the rocks were sorted.

Related Science Standards: 2
Related Workplace Readiness Standards: 3.5, 5.2, 5.5, 5.6, 5.8

Rocks for Sale! Students set up a “rock store” in which they display and try to sell rocks that they have collected. Alternately, they can use rock specimens from a classroom supply of New Jersey rocks.

Before they display their rocks, they must first sort them into various categories (based on softness, texture, composition, type, etc.). Students then arrange their wares and write descriptions of the rocks to use in computer-generated advertisements. Using classroom-made scrip or play money, the students conduct a “rock sale,” count their scrip, and determine their “profits.”

Related Science Standards: 1, 2, 5
Related Workplace Readiness Standards: 2.8, 3.1, 3.3, 3.8, 3.9, 4.2, 5.1, 5.4, 5.7

Classifying Minerals. Students place a group of minerals in a pile on a large piece of butcher block or mural paper and draw a circle around the pile of minerals. Ask the students to divide the group of minerals using *one* property. Suggest that the students consider the following properties:

- color
- luster
- texture
- hardness
- reaction to vinegar
- color yield in a streak test
- magnetism

For example, if *color* is the property, the students separate all of the minerals into two groups: light and dark. They place each new group near the original circle, draw circles around the new groups, and connect them with lines going to the original circle. Next, ask the students to divide each small group into even smaller groups using a *different* property, place them in a nearby spot on the large paper, and circle these groups. Students continue observing properties and classifying until each mineral has a circle around it. This activity helps students realize that every type of mineral has its own unique set of properties.

Related Science Standards: 1, 2, 5, 8
Related Workplace Readiness Standards: 2.2, 3.1, 3.2, 3.7, 3.8, 3.9, 3.11, 3.12, 3.13, 4.2, 5.4, 5.7, 5.8

Growing Crystals. Minerals are frequently found as part of the Earth's crust—either alone or within rocks. Minerals may form beautiful crystals. To acquaint themselves with minerals and crystals, students examine some real minerals and their crystal forms and locate photographs of missing varieties. They read science catalogs. Then students grow crystals using sugar and water, Epsom salts and water, or kosher salt and water. They set up experiments to discover which conditions are optimal for growth. They report their findings to the class.

Related Science Standards: 1, 2, 5
Related Workplace Readiness Standards: 3.1, 3.3, 3.7, 3.12, 3.13, 4.2, 5.4, 5.5, 5.7

Observing Soil. Ask the students, "What materials make up soil?" Encourage them to propose possible components of soil. Then the students collect soil samples outside. (Alternatively, you can simulate soil by combining commercially available soil mixtures.) Students examine their soil samples by spreading their material on a piece of white paper. Using a hand lens and tweezers or a simple probe (such as a toothpick), they separate the soil samples into groups such as:

- coarse materials (small stones or large, stony grit)
- fine materials (fine sand and clay)
- organic matter (decomposed leaves and twigs)

The students can relate their findings to their classmates. Students may extend this activity by letting their samples dry and then adding the samples to clear cups containing some water. They observe what happens when the mixture components settle. Students can further extend this investigation by comparing the composition of soils from different locations around the state and from different depths in the ground.

Related Science Standards: 1, 2, 5
Related Workplace Readiness Standards: 3.1, 3.3, 3.7, 3.12, 3.13, 4.2, 5.4, 5.5, 5.7

Indicator 3: Identify major sources and uses of water, discussing the forms in which it appears.

LEARNING ACTIVITIES: Grades K-2

Water-Cycle Plays. Student groups create and act out stories about the water cycle. Using some type of costuming or pictures on craft sticks, the students depict the travels of a water droplet through the water cycle, e.g.,

- A raindrop forms in a cloud and falls on a hill.
- It runs into a stream, which flows into a river, a bay, and the ocean.
- It evaporates and goes into a cloud, and the cycle continues.

Play audiotapes of environmental sounds (e.g., rain, rushing streams, or waves on a beach) while students act out their plays.

Help students realize that some water is "held up" in lakes, aquifers, and puddles and so is not flowing through the water cycle. Discuss with them how water is used by plants and animals (including humans). Students can collect pictures of how people use water and create a classroom display.

Related Science Standards: 1, 2, 4, 5
Related Workplace Readiness Standards: 2.2, 2.8, 3.13.8, 3.12, 3.15, 4.2, 5.7

Forms of Water. Students pour some water into a clear container, then mark how high the water level is. They observe what the water looks like in its liquid state. They then freeze the water until it is completely solid. Ask students to predict what will happen to the volume (height) of the water. They can draw pictures or write journal entries to show their predictions. The students observe the ice to see how the water has changed in appearance and size.

After marking the level of the ice, the students lightly cover the cups with plastic wrap (to prevent evaporation) and let the ice melt completely. They again observe the water and its volume. They compare the volume of the water in the liquid state before and after it was frozen.

Students discuss occasions when they have noticed that water seemed to disappear. They then fill two cups with water and cover only one cup with plastic wrap. They place both cups of water on a windowsill. The students observe and record the height of the water in each cup daily. What is happening to the water? Where has it gone?

Related Science Standards: 2, 5, 8
Related Workplace Readiness Standards: 2.7, 3.2, 3.3, 3.6-3.9, 3.12, 4.2, 5.7

Family Water Use. Students are rarely aware of how much water their own family uses. In this activity, students investigate and list ways their family consumes water daily and weekly. To visualize the amounts, students can fill buckets or gallon jugs with water and move them from one location to another.

Students can make story booklets and/or multimedia presentations relating the results of their study. Older students might analyze their results using graphs and other mathematical ways of summarizing the data.

Related Science Standards: 1, 2, 4, 5, 12
Related Workplace Readiness Standards: 2.2, 2.8, 3.13.8, 3.12, 3.15, 4.2, 5.7

LEARNING ACTIVITIES: Grades 3-4

Condensation. Give groups of students clear plastic cups partially filled with warm tap water. The students cover the cups with plastic "cling" wrap. For several minutes, they observe any changes in the appearance of the plastic film and record these changes with drawings, journal entries, etc.

At the end of four or five minutes, students place an ice cube on top of the plastic film covering the cup. Students record what they observe at regular five-minute intervals. Ask the students questions such as the following:

- What did you see on the underside of the plastic film as time went by?
- How did the water droplets get there?
- Where else have you seen water collect on surfaces?

Guide students into thinking about the occasions when they observe water and other moisture in their surroundings.

Related Science Standards: 1, 2, 4, 5
Related Workplace Readiness Standards: 2.22, 2.8, 3.1, 3.8, 3.12, 3.13, 3.15,4.2, 5.7

Earth, a Water Planet. Students estimate the percentage of the Earth's surface that is covered by water. Using a transparent grid overlay, students count the number of grid squares that cover land and the number of grid squares that cover water. They build and use graphs and tables to summarize their individual and class findings. They estimate the ratio of water surface to land surface or the percentage of water coverage (which they can find by dividing the number of water squares by the total number of squares).

Alternately, students can use a globe or a map and count the number of squares formed by longitude and latitude lines that are mostly water and those that are mostly land. What is the difference? What is the percentage of Planet Earth that is covered with water?

Related Science Standards: 1, 2, 4, 5
Related Workplace Readiness Standards: 2.2, 2.8, 3.1, 3.8, 3.12, 3.13, 3.15, 4.2, 5.7

Indicator 4: Collect and record weather data to identify existing weather conditions, and recognize how those conditions affect our daily lives.

LEARNING ACTIVITIES: Grades K-2

Day-to-Day Weather. Students realize that weather is all about them and influences their lives on a daily basis. From magazines and catalogs, students cut out pictures that represent daily weather conditions and pictures of various types of clothing suitable for different weather situations. Each day, they choose from this collection those pictures that correspond to the day's weather. For example, on a rainy day, students may select pictures of rain and rainy-day apparel such as raincoats, umbrellas, and even galoshes. They display the pictures in the class weather center and orally report the day's weather to the class. The students keep a weather journal containing drawings or pasted pictures.

Related Science Standards: 1, 2, 4, 5
Related Workplace Readiness Standards: 2.2, 2.8, 3.1, 3.8, 3.12, 3.13, 3.15, 4.2, 5.7

LEARNING ACTIVITIES: Grades 3-4

Weather Station. Students establish a class weather station using homemade or basic instrumentation such as a thermometer, barometer, rain gauge, wind vane, and anemometer.

Daily Weather Journals. Students write daily weather conditions in their weather journals. Entries might include

- readings from the instrumentation in their class weather station
- observations regarding cloud types, condition of air, amount and kind of precipitation
- present weather conditions obtained from a weather center (e.g., radio, television, or Internet)

In their journal entries, students could also write about the type of clothing they could wear outdoors and what activities they could do that day.

Students examine their data and learn to recognize certain patterns of seasons (e.g., storms vs. fair weather). Challenge students to examine their data more closely by asking them if there is any connection between their barometer readings and the prevailing weather conditions. The students can create video or multimedia presentations reporting their discoveries.

Related Science Standards: 1, 2, 4, 5
Related Workplace Readiness Standards: 2.2, 2.7-2.9, 3.1, 3.8, 3.12-3.15, 4.2, 5.4

Indicator 5: Compare different map projections, and explain how physical features are represented on each.

LEARNING ACTIVITIES: Grades 5-6

Map Projections. Students, organized into cooperative learning groups, gain insight into the characteristics that separate one kind of map projection from another. In classrooms equipped with videodisc players, multimedia computers, and reference materials, student groups retrieve information about gnomonic projections, cylindrical projections, and conic projections. They summarize their findings in a portfolio.

When given unlabeled sets of projections, students sort, identify, and explain uses of these projections.

Related Science Standards: 2, 4, 5
Related Workplace Readiness Standards: 3.8, 3.9, 3.14

Map Cutouts. Students examine two or more world maps produced by different projections and investigate how area is represented on these maps. From each map, they cut out Iceland, Mexico, Brazil, Australia, and Africa. Then they weigh each cutout with a sensitive balance. For each set of pieces from a projection, they use calculators to find the ratio of the weight of each compared to that of the Africa cutout. Next, students find the actual land areas for the countries and continents using an atlas or other source. They then calculate the ratio of the actual area of each country to that of Africa.

Students describe the effect on apparent area of the different projections. After doing related reading, they propose reasons for using projections that may produce distortions in apparent area.

(Alternatively, students can weigh the complete set of cutouts from a given map and compare their combined weight to that of a set of cutouts from a different map.)

Related Science Standards: 2, 5
Related Workplace Readiness Standards: 3.8, 3.9, 3.14

LEARNING ACTIVITIES: Grades 7-8

3-D Topographic Map. Students first examine topographic maps used in "real life"—e.g., maps used by people hiking the Appalachian Trail in New Jersey.

To help visualize the third dimension of contour/topographic maps, students create a 3-D model of an actual quadrangle. They first obtain basic topographic maps of Mount Saint Helens before and after its famous 1980 eruption. Working in pairs, one pupil creates the pre-eruptive mountain while the partner generates a post-eruptive model. Each student creates templates at selected levels of elevation on their maps, transfers the templates to corrugated cardboard, traces them, cuts them out, and glues them one layer on another to reconstruct the map in a third dimension. Each partner explains to the other how contour lines actually show shape and elevation at the same time. Holding the models up for edge-on viewing helps the students picture the original interpretation of the initial contour/topographic map.

Students examine stereograms of contour maps to visualize a 3-D interpretation of the isolines known as contour lines. Ask the students questions such as the following. How do lines indicate mountaintops, depressions, valleys, steepness, and flatness? Which way is downstream?

Related Science Standards: 2, 5
Related Workplace Readiness Standards: 1.1, 3.2, 3.7

Indicator 6: Identify major features of the earth's crust, the processes and events that change them, and the impact of those changes on people.

LEARNING ACTIVITIES: Grades 5-6

Hallway Mural. In this class project, students create a pictorial representation of major features of the Earth's crust as well as examples of weathering and erosion. From old magazines, the Internet, or CD-ROMs, students obtain pictures of crustal features such as mountains, volcanoes, canyons, plains, and plateaus. They also find examples of the natural processes of weathering and erosion that tear the solid earth down (including glaciers and glaciated areas, landslides and mud slides, and running water). Students place their collection of materials on a hallway mural. Ask them to imagine the West Coast of the United States on the left, the East Coast on the right, and features of the middle of the country in between the coasts. Students can add sketches and drawings of specific places to the mural.

Back in the classroom, students discuss different features of the Earth's crust, the processes of weathering and erosion that change the crustal features, and how those changes impact the life and ecology of the region.

Related Science Standards: 1, 2
Related Workplace Readiness Standards: 1.1, 2.3, 2.6, 3.2, 3.5, 3.15, 4.2, 4.3, 4.9

Sands from around the World. Students discover that they can learn the geologic history of a region by studying its beach sand. Using their eyes, hand lenses, or stereoscopic microscopes, students examine sands from many different beaches. They study properties such as composition, color, luster, texture, and grain size and shape. They record their observations in drawings and written notes.

Students then place their sand samples on a world map. They find common features in specific groups of sands. For example, they may study sands common to a geographic region, such as New Jersey or the East Coast of the United States. They may study lake or river sands, sands that are close to a particular mountain range, or sands that are predominantly a specific color.

Students learn that sand grains are tiny pieces of minerals, rocks, and shells that have been produced by weathering and erosion, and that the older grains are smaller and more rounded than the younger ones. The students use resource materials and their observations of the sand samples to determine possible origins of the sand samples. For example,

- Sands from the East Coast of the United States are composed mostly of quartz—an abundant, hard mineral originating in the Appalachian Mountain Range.
- Many black sands are volcanic in origin.
- The sands of island beaches are characterized by shell and coral fragments.

Related Science Standards: 2, 4, 5, 8
Related Workplace Readiness Standards: 2.2, 3.1-3.4, 3.7, 3.8, 3.12, 3.13, 4.2, 5.4, 5.7

LEARNING ACTIVITIES: Grades 7-8

Coastline Maps and Models. Using available resources (e.g., CD-ROMs, videodiscs, computer software, texts, and other publications), students investigate the characteristics of shorelines and the processes of weathering and erosion that change shorelines. After this review, students obtain maps (quadrangles) of Boothbay, Maine; Point Reyes, California; and Toms River, New Jersey. They examine the coastlines on these quadrangles, looking for answers to questions such as the following:

- Which coastlines are submergent? Emergent?
- Where are sandbars? What types are visible?
- What is a barrier island?

- How do ocean waves change a coastline?
- What erosional features are found along coastlines?
- How are the coastlines similar? How are they different?
- How do humans try to lessen the impact of waves and currents on shorelines?

Students set up stream tables. Using a mix of fine sand, coarse sand, and some gravel, they create a continent with a shoreline at one end of the tank. They add water to simulate an ocean:

- Waves striking the shoreline change its shape.
- Currents flowing by the shoreline also change it.

Students place groin and other impediments to erosion and watch for results. Afterward, students relate their modeling to their map studies.

Related Science Standards: 1, 2, 4
Related Workplace Readiness Standards: 1.1, 2.3, 2.6, 3.2, 3.5, 3.15, 4.2, 4.3, 4.9

Historic Maps. Erosion and transport of geologic material may only become significant over long periods of time. Students examine a series of historic maps (e.g., from the early, middle, and late 19th and 20th centuries) to study these natural processes and the effect of man-made structures on them. They use historic maps as a resource for studying changes such as the following:

- River sedimentation, delta building, and the effects of levees on these natural processes (using historic maps of New Orleans and the Mississippi Delta)
- The effects of waterborne sand movement and human intervention (using historic maps of Long Island, Sandy Hook, or New Jersey barrier islands)

Students present their findings in written or multimedia reports. Challenge them to predict future effects of erosion and transport of geologic material.

Related Science Standards: 1, 2, 4
Related Workplace Readiness Standards: 1.1, 2.3, 2.6, 3.2, 3.5, 3.15, 4.2, 4.3, 4.9

Rate and Time. Students study historic water erosion by using a topographic map of a feature formed by water erosion (e.g., the Grand Canyon, Niagara Falls, and the Hudson Canyon). They estimate a rate of erosion associated with the feature and then estimate the *time* it took for the feature to form. Students compare their estimates with authoritative estimates from stratigraphic data.

Challenge students to predict how such effects might produce changes to the Earth's crust in the distant future. They could present these predictions using drawings, maps, essays, and/or computer multimedia presentations.

Related Science Standards: 1, 2, 5
Related Workplace Readiness Standards: 2.6, 3.5, 3.9, 3.12

Indicator 7: Identify the age of fossils, and explain how they provide evidence that life has changed through time.

LEARNING ACTIVITIES: Grades 5-6

Fossils over Time. Student groups examine different sets of identified fossils that are representative of life during a particular period of geologic time. The students draw sketches of the fossils and determine the time and environment in which the organisms lived. They use CD-ROMs, videotapes, laser videodiscs, computer software, and other resources to learn about the life-forms represented by the fossil collection.

Student groups construct dioramas or create multimedia presentations that picture life during a particular period or era of geologic time. Students review the work of other groups to recognize how life has changed during the ages of geologic time. They can present their findings orally, in written form, or technologically through multimedia programs.

Related Science Standards: 1, 2
Related Workplace Readiness Standards: 1.1, 2.6, 2.7, 2.9, 3.5, 3.15, 4.2

LEARNING ACTIVITIES: Grades 7-8

Correlation of Rocks via Fossils. In this activity, students correlate rock strata from three locations through the identification of fossils found within each layer of rock. Explain to students the concept of correlation, a technique in which sets of rock layers are related positionally by age through the examination of the fossils contained in those layers.

Prepare the “puzzle” pieces that the students will correlate by following these steps:

- Create three columns that represent a cross section of rock layers “spanning” geologic time.
- Place sketches of fossils of the same time on the same level across the columns.
- Cut up the columns (separately) into puzzle pieces of one, two, three, or four layers.

Students rebuild the columns based on cross-referencing fossils and rock types. They then relate the fossils to a detailed geologic timescale that helps them realize how forms of life have changed over time.

Related Science Standards: 1, 2, 5
Related Workplace Readiness Standards: 3.1, 3.2, 4.3

Decay Simulation. Introduce the students to the concepts of simulation and the random nature of radioactive decay. Without using actual radioactive materials, students simulate radioactive decay by working in pairs using a large set of 12-sided dice or working as an entire class using two cubic dice per student.

- Students roll dice (representing atoms) and remove any 1s (atoms that have decayed).
- They count and record the number of dice remaining after the decayed atoms (the 1s) have been removed. (The counting represents the determination of the number of radioactive atoms remaining in the rock or fossil.)
- They continue this for 10 sets of rolls of the dice. (Each roll of the dice represents a constant time interval.)
- They graph the number of "atoms" remaining after given amounts of "time."

Students use their results to model finding a time interval (number of rolls of the dice) if the percent of radioactive atoms (dice) remaining is known. They can use the dice analogy to describe the radioactive dating of a specific sample using a specific radioisotope. Students can also find the "half-life" for the "decaying" dice or use computer software to graph the data and find an equation for the percentage of "atoms" remaining after a given time interval.

Related Science Standards: 2, 5
Related Workplace Readiness Standards: 2.8, 3.2, 3.9

Fossils and Sedimentation Estimates. As students study the age of fossils, they encounter the idea that some fossils may be dated using the age of the sedimentary rock in which they are found. Students examine samples of sedimentary rock and begin to propose a model for the laying down of sediment and the eventual transformation of sediment into rock (*lithification*). They visit a sedimentary formation or view photographs of one. Using their understanding of sedimentation and rock formation processes, the students estimate the total time required to lay down the sedimentary formation. They also consider the subsequent processes that brought the formation to its current condition. By associating time intervals with each part of the process, the students propose an estimated age for fossils that may be found in the observed formation. They then consult authoritative resources for the age of the observed outcrop and any fossils found in it and analyze the sources of error in their own attempt at estimating age.

Related Science Standards: 2, 5
Related Workplace Readiness Standards: 3.5, 3.8, 3.12

Indicator 8: Describe and explain the causes of the natural processes and events that shaped the earth's surface and interior.

LEARNING ACTIVITIES: Grades 5-6

Earthquake Model. As students read about and see videos of earthquakes, they become interested in the motions of the Earth's surface that produce earthquakes. Simulate these motions using sheet cakes baked in foil baking pans following the procedure outlined below.

- Cut a sheet-cake pan in half and keep it together with aluminum foil wrapped around the bottom and up over the edges.
- Place this pan in a second pan to provide a sturdy container for baking.
- Bake the cake using the directions provided with the cake mix and let it cool.
- Gently lift the pan-foil container from the uncut pan. (Be careful not to bend or break the cake!)
- Place the cake on a work surface and remove the foil.

Use the cake in the cut pan to model Earth's motions. Explain to the students that the deformation of the cake is analogous to the deformation of the Earth's surface. (Use a separate cake for each motion that is modeled.)

- *Divergent or rifting motions of crustal blocks*—Gently pull apart the two halves of a cake.
- *Lateral plate motion*—Gently move one half of the cake to the left along the cut in the pan while moving the other half to the right.
- *Compression effects*—Gently push the two halves together.

During each simulation, students should make careful observations and record them with sketches and written descriptions. Using images from video or CD-ROM sources, they compare these simulated earthquake effects to those produced by actual earthquakes.

Related Science Standards: 1, 2
Related Workplace Readiness Standards: 2, 3, 3.4, 4.1, 4.2, 4.6, 4.7, 4.9, 4.10, 4.12, 4.15, 5.1, 5.2, 5.4, 5.5, 5.8

LEARNING ACTIVITIES: Grades 7-8

Volcanism and Diastrophism. Students examine posters, photographs, models, videotapes, and multimedia computer software that depict the effects of

- *Diastrophism*—folding and faulting
- *Volcanism*—the movement and cooling of magma (which produces *intrusive structures*) and lava (which produces *extrusive structures*)

Individually or in small groups, the students create physical representations of diastrophism and volcanism using various materials.

- *Folding*—Students fold sets of stacked paper towels, cloth towels, or toilet paper to demonstrate upfolds (*anticlines*) and downfolds (*synclines*). They use modeling clay, layered with different colors, to create models of folded mountains such as those in northwestern New Jersey.
- *Faulting*—Using templates of fault blocks, they construct *footwall* blocks and *hanging-wall blocks*. They simulate movements of these blocks that result in normal *faults*, *reverse faults*, *horsts and grabens*, *fault block mountains*, etc.
- *Volcanism*—Using templates obtained from the U.S. Geological Survey, they build a model of a typical *stratovolcano* such as Mount Saint Helens.

Students tie all work to real-life examples by researching the impact of earthquakes (a result of movement along fault lines) and volcanic eruptions on the life of the individuals who experience them. What happened to people during and after the recent earthquakes in California or volcanic eruptions? Have events of this nature ever occurred in New Jersey?

Related Science Standards: 1, 2
Related Workplace Readiness Standards: 1.1, 2.2, 2.6, 3.1, 4.2

Finding the Epicenter. To simulate the way scientists use seismographic information, students plot data from a single identified earthquake. They indicate the location of the earthquake epicenter and the arrival time of the resulting P (*primary*) and S (*shear*) waves at seismic stations around the Earth. Using computer graphing or spreadsheet software, students construct a graph of travel time versus distance from the epicenter. They identify the relationship between distance from an epicenter and the arrival times of P and S waves.

Next, using seismograph data from three observing stations for an earthquake for which the epicenter is not specified, students calculate the distance to the possible epicenter for each observing station. The three distances define the radii of three circles centered on the observing stations (one circle for each station). Using the circles and a globe, students find the epicenter of the earthquake. If historic data rather than simulated data is used, students can research published information regarding the earthquake, its location, and any significant surface effects it may have produced.

Related Science Standards: 2, 4, 5
Related Workplace Readiness Standards: 1.1, 2.2, 2.6, 3.1, 3.2, 4.2

Indicator 9: Monitor local weather conditions and changes in the atmosphere that lead to weather systems.

LEARNING ACTIVITIES: Grades 5-6

Weather Journal. Students create daily journal entries of weather observations. They look out the window or step outdoors and make actual observations of weather phenomena. They record readings from a classroom weather center that includes a barometer, a maximum/minimum thermometer, rain gauge, a psychrometer, cloud charts, wind gauge, and wind vane. (Some of these instruments may be handcrafted.) Students can set up computer spreadsheets to make journal entries electronically.

As the year progresses, students discuss weather systems such as *highs* and *lows*. Students review their journals looking for patterns of temperature, pressure, and wind direction changes that match the descriptions of highs and lows. They relate their conclusions to the actual weather conditions that they recorded at those times. Students again review their journal entries to study *seasonal* weather conditions. Ask them to describe typical fall readings, winter readings, and spring readings.

Related Science Standards: 1, 2
Related Workplace Readiness Standards: 2.8, 3.9, 3.12, 4.3, 5.2

Dew and Frost. Students keep records of very local (*micrometeorological*) phenomena such as *dew* and *frost*. In individual journals or a class chart, students record temperature, relative humidity, wind conditions, the presence or absence of cloud cover, and the presence or absence of dew or frost. They use their observations to develop a model for conditions that lead to the formation of dew and frost. Students then use their model—coupled with their own observations as well as information from weather services—to predict when dew or frost may form.

Related Science Standards: 1, 2
Related Workplace Readiness Standards: 2.6, 3.7, 3.12

Internet Weather. Students use the Internet to become familiar with weather around the world. They share weather and climate details with school students in different regions. Project GLOBE is an example of a worldwide initiative that encourages students to gather and share data for scientific research.

Students can plot U.S. weather as a front moves from west to east and then calculate speeds along with changes that occur as the fronts move. For example, students can note the temperatures on various sides of the front. Daily weather maps are available on the Internet.

Related Science Standards: 1, 2, 4, 5
Related Workplace Readiness Standards: 2.2, 2.7, 2.8, 3.1, 3.8, 3.12, 3.13, 3.15, 4.2, 5.4

LEARNING ACTIVITIES: Grades 7-8

Weather Forecasting. Students use local newspapers or download weather maps and data regarding weather conditions from the Internet. They use this information to monitor the progression of air masses and fronts (with their associated weather) across the United States. Students select five major cities such as Seattle, Los Angeles, St. Louis, Boston, and Miami. They create a journal of each city's weather conditions (including temperature, air pressure, wind speed and direction, sky condition, and precipitation). They compare the daily weather maps with each city's weather for the same day. They attempt to identify patterns of passing systems and answer the questions such as

- What weather accompanies a high? a low? a passing cold front? a warm front?
- What is influencing the weather in the chosen cities?

Students can create a school weather forecast, which they post or read over the public address system.

Related Science Standards: 1, 2, 3
Related Workplace Readiness Standards: 1.1, 1.8, 2.3, 3.9, 4.9

An Approaching Low. Students first learn about the formation of various weather fronts (e.g., warm, cold, stationary, and occluded fronts), highs and lows, and associated cumuliform and stratiform clouds. They then track the passage of lows and highs across the country for an extended period of time using weather maps they collect from newspapers or download from the Internet (e.g., http://www.weather.com). By associating the position of the low or high, students are able to understand and even predict the weather of major U.S. cities—and of their own city's weather. Then when they observe the clouds overhead, the local temperature, humidity, wind direction, and atmospheric pressure, they might announce to their classmates: "That was a low that just passed" or "We are experiencing the weather associated with a high right now!"

Related Science Standards: 1, 2, 3
Related Workplace Readiness Standards: 1.1, 1.8, 2.3, 3.9, 4.9

Indicator 10: Investigate the composition, cycling, and distribution of the world's oceans and other naturally occurring sources of water.

LEARNING ACTIVITIES: Grades 5-6

Density Currents. In this activity, students simulate density currents, the up-and-down movement in the oceans that are generated by differences in temperature and/or salinity. First, they place tepid water in a plastic shoebox to a depth of 6 cm. Next, they insert pushpins midway up the sides of two 3-oz paper cups. They fill one cup with ice water colored by several drops of blue food coloring and fill the other cup with hot water colored by several red food drops. The students place the cups in the "ocean" with the pins facing each other and gently pull the pins out. The students observe the resulting currents for several minutes and sketch their observations after each minute. Students repeat the action with a new ocean, fresh water in one cup, and very salty water in another cup. After they pull the pins from the cups, they observe the new currents as before.

Students summarize their work and relate their observations to real-life examples.

Related Science Standards: 1, 2
Related Workplace Readiness Standards: 1.1, 2.3, 3.1, 3.2, 3.7, 4.2, 4.3, 4.9, 5.3, 5.4

Upwelling and Downwelling. Using resources such as articles, books, videotapes, CD-ROMs, videodiscs, and Internet access, students investigate the influence of persistent winds, the Earth's rotation, and shoreline orientation on coastal *upwelling* and *downwelling*. They research the impact of upwelling and downwelling on the climate, weather, and fishing industries of the west coasts of Africa and the American continents.

Next, students simulate these concepts. They create a model of the ocean basin on a sheet of paper. Windows cut out of this top sheet allow a specially designed "wheel" to turn below and relate wind directions to coastal upwelling or downwelling above and below the equator. Students summarize their discoveries through charts, posters, oral or written reports, or multimedia presentations.

Related Science Standards: 1, 2
Related Workplace Readiness Standards: 1.1, 2.3, 3.1, 3.2, 3.7, 4.2, 4.3, 4.9, 5.3, 5.4

LEARNING ACTIVITIES: Grades 7-8

Ocean Surface Currents. The surface currents of the major oceans flow in large circular patterns (gyres) that are very similar to the constant wind patterns that generate these currents. Using printed materials, CD-ROMs, videodiscs, videotapes, and other sources, students review how gyres play an important role in redistributing heat from the lower latitudes to higher latitudes, thereby influencing air temperature, weather, climate, world exploration, and commerce.

Next, students simulate the influence of the wind on ocean currents by filling a clear, shallow container (such as a glass pie plate) with water. They sprinkle paper circles (hole punches or confetti) on the still surface. They each practice creating clockwise and counterclockwise gyres by gently blowing through soda straws. They hold the straws at a very low angle—barely touching the water's surface. Then, groups of two, three, or four students practice generating more than one gyre in the same container. Give each group an outline map of the world's oceans that has the prevailing winds upon it. Students place the dish over the map and attempt to simulate currents influenced by the indicated winds. Withdrawing the dish, students sketch in the ocean currents and match their work to the patterns discovered in their original review.

Related Science Standards: 1, 2
Related Workplace Readiness Standards: 1.1, 2.3, 3.1, 3.2, 3.7, 4.2, 4.3, 4.9, 5.3, 5.4

Seawater Composition. To help visualize the composition of seawater, students weigh out samples of chemical compounds that could be extracted from seawater (e.g., sodium chloride, potassium chloride, calcium chloride, and magnesium sulfate).

- They first calculate the volume of their classroom.
- Using data on the percent composition of seawater, they calculate the weights of each compound that would be present in a "tank" of seawater the size of the classroom.
- They then weigh out the calculated masses of these compounds.

Students research the properties and applications of these compounds that provide the ions typically found in seawater. They can also investigate the challenges of desalination.

Students follow safety procedures and learn to use the safety equipment required when working with chemical compounds.

Related Science Standards: 2, 5, 8
Related Workplace Readiness Standards: 3.2, 3.5, 5.5, 5.7

LEARNING ACTIVITIES: Grades 9-12

Ice Bubbles. Students read about how ice cores are extracted and how the layers are dated. They review data on the composition of air bubbles (especially carbon dioxide) from ice cores. They then graph the data and write a description of changes in the atmosphere over the time intervals represented by the core samples. With this background, they can evaluate information about the "greenhouse effect" that they find in magazine and newspaper articles and television programs. They can visit global warming Web Sites for additional information to use in a debate on whether global warming is or is not occurring today.

Related Science Standards: 2, 5, 12
Related Workplace Readiness Standards: 2.6, 2.9, 3.5, 3.12

Stratigraphy. Stratigraphers look at cross sections of earth as revealed in rock layers such as those exposed in water gaps like the Delaware Water Gap or highway cuts like those on Route 23 in Sussex County. These layers tell a story about the geologic history of the area. Before visiting a site like these examples, distribute stratigraphic cross sections of locations in the United States. "Walk" students through an analysis and then turn them loose on other examples. Challenge them to identify the oldest layer—and the youngest.

Then take students to a site in New Jersey. While there, they sketch, photograph, or record pictorially a cross section of that spot. Back in the classroom, they interpret what they saw individually and in group discussion. Unconformities, top and bottom features, and the influence of folding, faulting, and volcanism all add complexity to the analysis.

Sedimentation. Students observe patterns of sedimentation by using sedimentation tubes and a mixture of fine, medium, and coarse sediment. After they add the sediments to water in the tube, they shake and observe the settling. Ask them to answer the following questions: What size particles settled out first? Which settled out last? Why?

Related Science Standards: 2, 5
Related Workplace Readiness Standards: 1.2, 3.2, 3.7, 3.9

Indicator 12: Use the theory of plate tectonics to explain the relationship among earthquakes, volcanoes, mid-ocean ridges, and deep sea trenches.

LEARNING ACTIVITIES: Grades 9-12

Plate Puzzle. In this activity, students recognize the close relationship of earthquakes and volcanic events to the edges of the Earth's crust known as plates. After reviewing the major crustal plates, distribute picture puzzle pieces that (when assembled) become a world map with the plate edges evident. Students use printed materials, CD-ROMs, videodiscs, and computer simulations at cooperative learning centers to investigate the behavior of the Earth's crust at these plate edges. Challenge them to answer the following questions:

- What happens where plates converge?
- What happens where they diverge?
- How do these behaviors relate to volcanic and earthquake activity?

Students access real-time information about earthquakes from Internet sites. On a large wall map, they place pushpins at locations revealed by the Internet addresses, using one color for earthquakes and another color for volcanic eruptions. If the map is left posted for an extended period of time (perhaps years), the pushpins marking action at these plate boundaries will outline the plate edges. The plates will become more and more recognizable.

Related Science Standards: 2, 3, 5
Related Workplace Readiness Standards: 2.1, 2.3, 3.2, 3.12, 4.1

Plate Edges. Because plates are not directly observable, students work with data that illustrate and support the plate tectonics theory. Provide students with the latitude, longitude, and magnitude data for major earthquakes occurring over the last 50 to 75 years. Students plot the location and magnitude of these earthquakes on a world map and identify a pattern in the distribution of such earthquakes. They try to explain any pattern they see. Students may collect images of geological features from the areas where quake frequency is high.

Students then mark the locations of significant volcanic activity on the world map. They explain how contemporary geologic events indicate the existence of tectonic plates.

Related Science Standards: 2, 3, 5
Related Workplace Readiness Standards: 2.6, 3.2, 3.5, 3.9

Indicator 13: Explore how weather phenomena and human activity are interrelated.

LEARNING ACTIVITIES: Grades 9-12

Snow Removal. Everyone always talks about the weather, but some people have to do something about it; they have to remove snow from roads.

Students search almanacs and databases of weather records to locate historical snowfall data, preferably by monthly accumulation. Then they graph the data. Next, they locate local municipal, or county budget records and identify the annual cost of snow removal for the local municipality. They can plot the snow removal costs on the same graph as the snowfall data. Students relate annual snowfall to the annual cost of snow removal over a several-year period.

Challenge the students to find and account for unexpected shifts in budgeting.

Related Science Standards: 2, 4, 5
Related Workplace Readiness Standards: 2.6, 3.5, 3.9, 3.12

Hurricanes and Major Storms. Excellent videotapes from many commercial sources depict hurricanes, tornadoes, winter storms such as northeasters, and other major weather happenings. Even Hollywood with "Twister" provides the hook to ensnare student interest. Use videos to introduce the nature of these storms. What is a tornado? hurricane? northeaster? a low?

Follow this discussion with specific studies of major weather events.

- Students role-play as weatherpersons with the National Hurricane Center and track hurricanes such as Andrew or Gordon. Using NOAA hurricane tracking maps, students plot 24 hours of information at a time. At the end of each 24-hour period they issue watches and warnings and attempt to predict an approximate landfall. Should areas be evacuated? This is a multimillion dollar decision! Andrew is quite predictable, but the wandering path of Gordon will challenge students. When landfall actually occurs, students research the financial and human losses incurred. What happened at the point of landfall? How widespread were the losses? Were human lives lost? What happened to wildlife habitats?

- Using NOAA's data for major storms, students plot the path of major northeasters such as the Storm of the Century (1993) or the Blizzard of (1996). The position of the track in relation to the Atlantic Ocean and the eastern coastline dictates snow depths. Students record snow depths at different locations on a surface map of the eastern United States. Adding isolines at intervals helps students see the relationship of the storm track to the total snowfall.

Through written reports or multimedia presentations, students describe meteorological events and the serious impact such phenomena have on all facets of human experience.

Related Science Standards: 1, 2, 4, 5
Related Workplace Readiness Standards: 1.5, 1.7, 2.1, 2.10, 3.1-3.3, 3.11, 4.5, 4.6, 4.7, 4.9

Indicator 14: Identify and explain factors that influence water quality needed to sustain life.

LEARNING ACTIVITIES: Grades 9-12

Water Quality. Students plan a trip to a local water treatment plant or a sewage treatment plant to learn about water quality and its relation to the quality of human life.

Students conduct a long-term study of water quality. They periodically sample the pH, temperature, dissolved oxygen, and CO_2 content of a nearby river, stream, lake, or of the ocean. The class divides into teams, each with specific responsibilities. Explain to each group the appropriate scientific protocol related to their task or have the students download protocols found at the *Project GLOBE* Web site. Obtain test kits for field and classroom studies of both qualitative and quantitative measures of water samples from scientific supply houses.

Students use computers to record, store, and present their findings.

Related Science Standards: 2, 4, 5, 8
Related Workplace Readiness Standards: 1.3, 1.7, 2.4, 2.7-2.9, 3.1-3.15, 4.1, 4.2, 4.7, 5.7

Nonpoint Source Pollution. In a field study of nonpoint source water pollution, students begin by examining school property for evidence of this type of pollution. They look for runoff from parking lots, lawns, and playing fields. They organize their data by the type of pollutant that may be present and its estimated quantity. Later, they identify how nonpoint source pollutants enter the water cycle in the local community. They develop a community map showing where this pollution begins to concentrate in noticeable levels.

Students trace the effects of nonpoint source pollutants on area rivers, estuaries, and the ocean. Challenge them to propose realistic approaches for reducing this type of water pollution.

Related Science Standards: 2, 5
Related Workplace Readiness Standards: 3.7, 3.8, 3.11, 3.13, 4.2

SCIENCE STANDARD 11

All students will gain an understanding of the origin, evolution, and structure of the universe.

INTRODUCTION

This standard opens the doors of space science so that students may come to understand the relationship of their planet to the solar system and to the universe beyond. For this standard to be meaningful, students are introduced to **current interpretations** of the origin, structure, and evolution of the universe.

The inclusion of this standard acknowledges the subjective and affective meaning that can be drawn from a scientific explanation of the origins of the Earth and universe. The role of scientific method and the importance of good data become critical in developing understanding relative to events that predate the existence of the Earth and span scales of distance larger than the Earth itself.

In attaining this standard, students must become aware of the apparent motions of objects in the heavens and how these may be accounted for with a consistent model. This model must enable individuals to describe the causes of seasons, tides, and eclipses.

This standard provides the opportunity for students to generalize their understanding of scientific principles and apply these to settings beyond the surface of the Earth. The central role of gravity in accounting for the motions of objects in the solar system is extended to seeing gravity as the shaper of planetary, solar, and stellar evolution.

In order to attain this standard, students must apply their understanding of basic physical science principles to data that has been obtained remotely. The most interesting data is obtained by others and cannot be acquired directly in the school laboratory. Using such data provides a direct experience depending upon other investigators. Since much of the data is obtained through the application of advanced technology, class work relative to this standard provides opportunities to explore the interface of science and technology. **There should be opportunities to investigate the societal application of technologies originally developed in support of scientific investigation.**

DEVELOPMENTAL OVERVIEW

Young children must be guided in careful observation of the apparent motion of objects in the sky. Their growing awareness of direction, points of the compass, and location needs to be associated with the rising and setting of the sun and moon. Before grade 4, students can observe the phases of the moon to find the pattern of the moon's apparent shape and location in the sky. The need for and development of a model to account for the apparent motions can flow naturally from student awareness of celestial phenomena.

It is important that students have an opportunity to relate observations, or data, to the standard model of the solar system. The relative positions and sizes of the planets should be part of each student's understanding in the sense that the student knows where to find this information and knows how it was obtained by scientists. The on-going space science investigations supported by NASA are a source of current information that enable teachers to make the standard model as relevant as a state highway map.

Middle-school students begin to acquire a range of scientific understandings that can be applied to making sense of the data used by astronomers and space scientists. High-quality visual spectrum images are only a part of the data that has revolutionized our understanding of the solar system and of the universe. By grade 8, students can begin to examine the quantitative descriptions of gravity and of the other forces that space scientists take into account as they examine data from Earth-based and space probe sources.

After grade 8, instruction must be planned to help students understand the process of developing consistent explanations for observations of the solar system and the world. This planning must allow for students to develop usable concepts of gravity, magnetic fields, and electromagnetic spectra. Students must be allowed enough time and experience to make these fundamental concepts their own. Then they will successfully apply these in contexts such as relating stellar spectra to models for stellar and cosmic evolution. Students in high school will also begin to examine the issue of costs versus benefits when doing large-scale, technology-supported science such as that required in astronomy and the space sciences.

DESCRIPTIVE STATEMENT

The study of science should include a study of the planet Earth and its relationship to the rest of the universe. This standard describes what students should know about the composition of the Earth and the forces that shape it, while *Science Standard 11* describes what students should know about astronomy and space science.

CUMULATIVE PROGRESS INDICATORS

By the end of Grade 4, students

1. Observe and identify objects and their apparent motion in the day and night sky.
2. Relate the motions of the earth-sun-moon system to units of time (days, months, seasons, years).
3. Construct a model of the solar system.

Building upon knowledge and skills gained in the preceding grades, by the end of Grade 8, students

4. Describe the physical characteristics of the components of the solar system, and compare the earth to other planets.
5. Explain how naturally occurring events on earth are related to the positions of the sun, earth, and moon.
6. Describe the technologies used to explore the universe.

Building upon knowledge and skills gained in the preceding grades, by the end of Grade 12, students

7. Construct a model that accounts for variation in the length of day and night.
8. Evaluate evidence that supports scientific theories of the origin of the universe.
9. Analyze benefits generated by the technology of space exploration.

LIST OF LEARNING ACTIVITIES FOR STANDARD 11

GRADES K-4

Indicator 1:

GRADES K-2
Objects in the Day and Night Sky
Shadow Persons

GRADES 3-4
Connect the Stars
Shadow Sticks
Moon Journals

Indicator 2:

GRADES K-2
Day and Night
Flowerpot Clock

GRADES 3-4
Four Seasons: A Tropical Year
Sun Domes
Angle of the Sun's Rays
Seasons and Length of Day

Indicator 3:

GRADES K-2
The Solar System in the Gym
Day and Night Sky

GRADES 3-4
Mission to Mars
Distances in the Solar System Model
Scale Model of Earth/Moon Volumes
Walk through the Solar System

GRADES 5-8

Indicator 4:

GRADES 5-6
Inner and Outer Planets
Planet Atmospheres
Planet Gravities

GRADES 7-8
Comparing Distances and Sizes
Impact Craters
Planet Sorting
The Creature Feature

Indicator 5:

GRADES 5-6
Modeling Events
Tides

GRADES 7-8
A Mathematical Model of Eclipses
Tide Tables

Indicator 6:

GRADES 5-6
Build Your Own Telescopes
Space Shuttle Simulation

GRADES 7-8
Radio Astronomy
Probe Data
Pictures from Space

GRADES 9-12

Indicator 7:

Sunlight and the Earth
Estimating Day and Night

Indicator 8:

Big Bang
Expanding Universe
Stellar Evolution

Indicator 9:

Cost-Benefit Analysis
Courtroom Drama

Indicator 1: Observe and identify objects and their apparent motion in the day and night sky.

LEARNING ACTIVITIES: Grades K-2

Objects in the Day and Night Sky. Demonstrate the concepts of sun, moon, and stars with visual aids such as big books, posters, and pictures. Students draw pictures of objects that they can see in the day sky and night sky. They also identify pictures and diagrams of these objects.

Afterwards, students put on a play in which classmates guess the answers to questions like "What am I?" and "Do you see me in the day or night?"

Related Science Standards: 1, 2
Related Workplace Readiness Standards: 2.2, 2.8, 3.1-3.8, 3.15, 4.2, 5.7

Shadow Persons. Working in teams of two, students go out in the school yard to trace their shadows. One student stands facing south while his or her partner traces the resulting shadow on the asphalt or on a large piece of paper. The students return to the same spot several more times during the day, especially at noon. Each time they sketch the new shadows on the pavement. Students draw pictures of the sun's position in the sky at the same time they observe their shadows. They answer questions such as the following:

- How did your shadow change?
- Are any shadows on top of each other?
- Where was the sun each time you sketched your shadow?
- How did the sun's position change?
- Which of the shadows you drew was the shadow of local noon?

Post the students' shadow persons in the school hallway.

Related Science Standards: 1, 2
Related Workplace Readiness Standards: 2.2, 2.8, 3.1-3.8, 3.15, 4.2, 5.7

LEARNING ACTIVITIES: Grades 3-4

Connect the Stars. Give student groups pieces of paper with stars in various positions. The students connect the stars to make an object and write a story that tells how the object entered the sky. Student groups act out their stories about their constellations.

Next, students design constellation projectors using black construction paper and cardboard cylinders (such as oatmeal containers). They cut out black disks just a little larger than the end of the cylinder, punch holes to depict actual constellations, and tape these disks to one of the open ends of the tube. In a darkened room, students use flashlights to project their constellations on the classroom ceiling. As an extension activity, students punch holes outlining other objects. Classmates try to guess each new constellation.

The ultimate extension would be to obtain a StarLab planetarium. StarLab is a large, inflatable planetarium that sets up in minutes. It can be obtained on loan from museums with outreach educational programs. Students crawl in and observe the night sky while appropriate music is played in the background. They identify constellations discovered through their own projects. Students listen to myths that reflect how different cultures regard the constellations. Examples exist in the folklore of Ethiopia, China, Native America, etc. Students ultimately develop some form of report that summarizes their discoveries about constellations and accompanying folktales.

Related Science Standards: 1-4
Related Workplace Readiness Standards: 2.2, 2.7, 3.1-3.8, 3.12, 4.2, 4.9, 5.7

Shadow Sticks. By following the steps below, students record the apparent motion of the sun across the sky by tracing the shadow of a short, upright stick at regular intervals.

- Facing magnetic north, they place a large sheet of paper on the ground in a location where the sun will shine all day.
- They draw a box around the sheet so they can put the paper back in the same place each time they take a reading.
- They secure a stick or straw in a clump of clay and place it midway along the edge of the paper that faces south.
- Then they trace a line around the shadow of the stick.
- They label the time.

Students repeat the above procedure every hour (or at least three times) during the day.

They can repeat this activity twice during the week; once a week for several weeks; once a month for several months; or on astronomically important days, such as the fall and spring equinoxes or the winter and summer solstices. If the students use sheets of clear acetate instead of paper, they can place weekly, monthly, or seasonal readings on top of each other on the overhead projector and compare them.

Students look for the relationship between the direction of the shadow and the location of the sun, patterns in the movement of the shadows from hour to hour, and the relationship between the time of day and the length of the shadows. They examine the change in length during various one-hour intervals and also consider the changes in the direction of the angle during the day. They identify patterns that emerge during long-term observations. Students plan how to organize their observations so as to share them with students living at other latitudes. They may use e-mail to share their results or to plan joint observations with students who live elsewhere. With students from other locations, they look for similarities, differences, and applications of their observations.

Related Science Standards: 1, 2, 5, 9, 10
Related Workplace Readiness Standards: 3.3, 3.7, 3.9, 3.12, 5.3, 5.7

Moon Journals. To determine students' prior knowledge, ask them to generate a list of what they know about the apparent motion of the moon in the day and night sky. After this introductory activity, students look for the moon every day and night for a period of two months. They keep a journal of their moon observations. At the beginning of this investigation, students discuss what information is important to note in their journals. They might include the following:

- date and time of observation
- a drawing of the moon
- the moon in relation to a fixed point, such as a tree, telephone pole, horizon, or sun
- weather conditions

Encourage students to design their own journal formats, using computers when possible.

Daily, students share their journal entries with the class. Each day an entry can be posted on a bulletin board to create a classroom moon journal. In this way, all students have the opportunity to notice patterns in the moon's appearance over time.

Periodically, students discuss the patterns they have been observing. They discover patterns in the appearance of the moon and its position in the sky.

After a month, students transfer their journal drawings of the moon's appearance onto a calendar. This helps them synthesize their observations. They share with each other what they now know about the moon. They compile a class list of "Moon Truths" and compare it to the list they generated at the beginning of the unit.

Students test their "Moon Truths" with another month of lunar observations. They verify the patterns, nullify them, or discover new ones.

Related Science Standards: 1, 2, 5, 9
Related Workplace Readiness Standards: 2.7, 3.1-3.9, 3.12, 4.2, 5.7

Indicator 2: Relate the motions of the Earth-sun-moon system to units of time (days, months, seasons, years).

LEARNING ACTIVITIES: Grades K-2

Day and Night. This activity simulates day and night and demonstrates the effects of sunlight on Earth. Using small building blocks, students create a model of their home, school, street, or neighborhood. They include buildings, plants, people, and animals.

To simulate daytime, the students shine flashlights onto the block model. They move the appropriate pieces to depict the actions of living things during daytime. They notice that the flashlight is giving off light, and they identify its effect on the model town.

Next, the students turn off the flashlights, simulating nighttime. They answer questions such as the following:

- What changes take place in the environment?
- How do the actions of living things change?

When flashlights are turned on and off at regular intervals, students begin to realize that the orderly occurrence of day and night affects life on Earth.

Related Science Standards: 1, 2, 6
Related Workplace Readiness Standards: 3.3, 3.7, 3.9, 5.3, 5.7

Flowerpot Clock. Students create a sun clock using a flowerpot and a long stick. First, they secure a long stick in the hole at the bottom of the flowerpot by placing it in a ball of clay. Next they place the pot in the sunlight outside. To maintain proper orientation, they make a mark on the pot to match a mark on the ground.

During the course of the day, they watch the shadow of the stick move along the rim of the pot. Every hour, they mark the spot of the shadow on the rim of the flowerpot and record the time of day. The next day, when they put the pot in the same place, aligning the marks, they are able to tell the approximate time by reading the location of the shadow on the pot.

Supporting Educational Research: Adapted from a *Young Astronauts* activity (Young Astronauts Council, Washington, D.C.)
Related Science Standards: 1, 2, 5, 9, 10
Related Workplace Readiness Standards: 3.3, 3.7, 3.9, 3.12, 5.3, 5.7

LEARNING ACTIVITIES: Grades 3-4

Four Seasons: A Tropical Year. Students draw positions of the sun in a seasonal background throughout the year no less than twice a month *at the same time each day*. (Hopefully, they will have an unimpeded view of the southern sky from the school yard.) Students enter the date in their journal and note the sun's height in the sky each time. As time goes by, they answer questions such as the following:

- Is there a relation between the height of the sun and the season of observation?
- Is there a relationship between seasons and weather phenomena?

As the school year draws to a close, students generate a multimedia summary of their findings. In this summary, students compare the position of the sun with the seasons amongst any other findings. Ask the students: "If you continue this study through the summer as well as the fall, winter, and spring of the next school year, and therefore observe a second first day of spring, what unit of time will have passed?" A full revolution of the Earth around the sun has occurred; this unit of time is called a *tropical year*.

Related Science Standards: 1, 2, 10
Related Workplace Readiness Standards: 2.8, 3.1-3.8, 3.15, 4.2, 4.9, 5.7

Sun Domes. In this investigation, students plot the apparent path of the sun across the sky during the day and predict the sun's path during different seasons of the year. They first discuss what they know about the apparent path of the sun during the day. They generate a list that they will return to at the end of their investigation. Some ideas may include time and direction of sunrise and sunset, and time when the sun is directly overhead.

Then students make a sun dome using a clear, plastic hemisphere (e.g., the bottom section of a clear, round plastic soda bottle whose black bottom has been popped off). They tape the hemisphere to a square piece of cardboard large enough to fit the hemisphere. Then they place the dome (representing the celestial sky) on the square so that the top of the dome is directly above the intersection of two perpendicular lines labeled with the cardinal directions (N, S, E, W) on the cardboard.

At the beginning of a sunny school day, students take their sun domes outside and place the domes on the ground, correlating north on their sun domes with north on their directional compasses. They draw a chalk line around their sun dome squares so that they can return to the same place later that day. Using a permanent marker, they touch the marker on the plastic dome so that the pen's tip casts a shadow onto the center of the dome (the intersection of the two lines drawn on the cardboard).

They make a mark with the tip of the pen and label it with the time. (This mark represents the position of the sun in the sky at that particular time.) In the same manner, students take sun dome readings every half hour during the rest of the day. Between readings, students predict where the next dot will be on the dome, or where the sun will appear in the sky next. They also predict at what time they think the sun will be at its highest. At the end of the day, students make generalizations about the pattern of the apparent path of the sun. They extrapolate the path of the sun to where it rose and where it will set. They predict how the pattern might change in a different season.

This activity can be done once in the fall, once in the winter, and once in the spring. In the spring, the students revisit their original list of what they knew about the sun and compare it with what they know now.

Related Science Standards: 1, 2, 4, 5, 9
Related Workplace Readiness Standards: 2.7, 2.8, 3.1-3.8, 3.12, 5.4, 5.7

Angle of the Sun's Rays. In this two-part activity, students investigate how the angle of the sun's rays influences the amount of heat and light received on Earth.

First, the students observe how the angle of the sun's rays changes during the course of the day by following these steps:

- Using a sharp pencil point, they punch a small, round hole in a piece of paper or cardboard.
- They place this paper in a southern window, where the sun's rays will shine through the hole and onto a large piece of white paper on the floor, table, or windowsill.
- They draw the outline of the spot where the beam of light shines on the paper and label the date and time inside the outline.

Students repeat this procedure periodically throughout the day. They note changes in the placement and size of the outline over time.

Next, the students investigate the effect of the angle of the sun's rays on heating the Earth's surface. They design and conduct experiments that compare the temperature of a substance when heated by a light source at varying angles. They use materials such as

- heat lamps (simulating the sun)
- sand, soil, or water (Earth surface materials)
- thermometers or temperature probes and corresponding computer software

In these experiments, the students could tilt the light at an angle while keeping the surface material sitting flat, simulating our perspective from Earth. Alternately, the light could be constant and students could place the surface material in a tilted tray, simulating the perspective from space.

Using spreadsheets and graphing skills, students analyze their data and summarize the results.

Related Science Standards: 1, 2, 4, 5, 10
Related Workplace Readiness Standards: 2.2, 2.7, 3.1-3.3, 3.6-3.9, 3.12. 4.2, 4.9, 5.3, 5.4, 5.7

Seasons and Length of Day. Students investigate the relationship between length of day and seasons. Throughout the school year, students record times for sunrise and sunset. (They get the data from newspapers, television, or the Internet.) The students look for patterns and relationships by examining their charts. Specifically, they study correlations between length of day and the seasons.

Simultaneously, students investigate the location of the sun as close to sunrise and sunset as possible. Facing north, they record the location of the sun as it rises and again as it sets. They repeat this procedure, going back to the same location once a month throughout the year. They draw or write their observations, giving landmarks for the important points (due east, sunrise, due west, and sunset). Students observe that the sun both rises and sets farther north in the spring and summer than in the winter, thus creating a longer day in the spring and summer.

Next, students investigate the relationship between the length of time that the sun shines on Earth and the amount of heat received by the Earth. They design and conduct experiments measuring the temperature of a substance heated for varying amounts of time using the following materials:

- heat lamps (simulating sunlight)
- sand, soil, or water (Earth surface materials)
- thermometers or temperature probes and corresponding computer software

Using spreadsheets and graphing skills, students analyze their data and summarize the results.

These activities help students understand how the length of day—and therefore the amount of sunlight shining on a portion of the Earth—influences the seasons.

Related Science Standards: 1, 2, 4, 5, 9, 10
Related Workplace Readiness Standards: 2.2, 2.6, 3.3, 3.5-3.9, 3.12, 5.3, 5.4, 5.7

Indicator 3: Construct a model of the solar system.

LEARNING ACTIVITIES: Grades K-2

The Solar System in the Gym. In this activity, students simulate the solar system in the school gymnasium. They become planets, moons, comets, and asteroids. (Perhaps art class might provide the props to turn this escapade into a ballet of the planets, especially if appropriate music accompanies the activity.) Actively direct the action, so that the movement of the members of the solar system are appropriate in relation to the sun.

Related Science Standards: 1, 2
Related Workplace Readiness Standards: 3.1-3.8, 3.12, 3.15, 4.2, 5.7

Day and Night Sky. Students look at the sky during the day (being careful not to look directly at the sun). They draw pictures of the sky that they see, including drawings of the sun, the moon (if it is out), clouds birds, and airplanes. Over time, they make several observations and drawings of the daytime sky. They follow up this activity with a discussion of the properties, locations, and movements of the objects they have drawn. Ask them questions such as the following:

- What color is the sky at sunrise? at sunset?
- Where does the sun appear in the morning? in the afternoon?
- Do you notice any patterns in the sun's motions?
- What activities do people and animals perform in the daytime?

Next, students look at the sky at night, making periodic observations. They draw the night sky, including the moon and the stars. (Cray-pas or colored pencils on black paper are effective.) Again, ask them questions about the properties, locations, and movements of the objects they have drawn:

- What shapes of the moon have you seen?
- What colors of the moon have you seen?
- What features of the moon's surface have you noticed?
- Where have you seen the moon?
- How does the moon seem to move in the sky?
- How would you describe the color and brightness and colors of the stars?
- What have you noticed about the movement of stars?
- Do you notice any patterns in the stars' and moon's motions?
- What activities do people and animals do at night?

Related Science Standards: 1, 2
Related Workplace Readiness Standards: 3.2, 3.7, 3.9, 5.3, 5.7

LEARNING ACTIVITIES: Grades 3-4

Mission to Mars. Mars exploration has been in the spotlight recently. Two spacecraft, the *Mars Global Surveyor* and the *Mars Pathfinder*, were launched in 1996, and the *Mars Surveyor Orbiter* and *Lander* missions are planned for the near future. These space missions send back to Earth important (and exciting) information about Martian atmosphere, weather, climate, magnetic field, surface composition, and surface features such as polar caps and river channels. NASA revealed that a meteorite from Mars was found that possibly contains evidence of primitive life there. The continued cooperation between the Russian and American space programs has led to knowledge about how the human body adapts to long-term habitation in zero gravity.

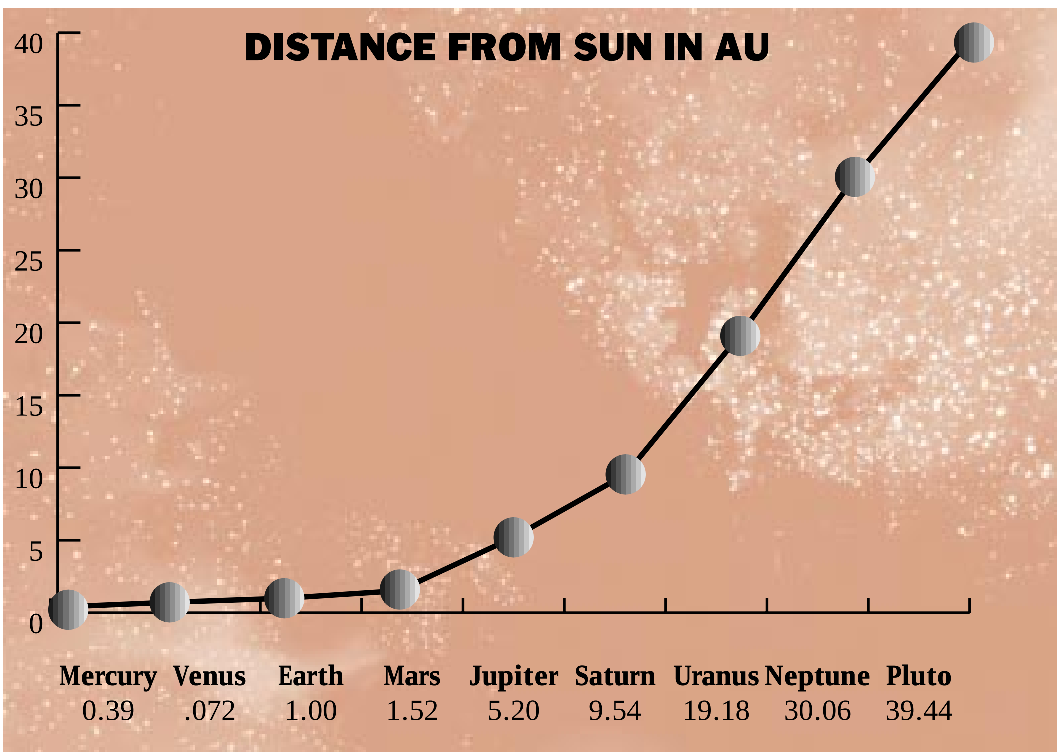
In this research activity, students learn more about Mars and the Mars exploration program by simulating a mission to Mars. First, they discuss humans' basic needs for survival. Then they research the characteristics of Mars by visiting the library or the many informative Web sites on the Internet. With an understanding of space flight and the Martian environment, they develop a plan for building a community on Mars. Students use the most up-to-date information and technology as they apply their problem-solving and decision-making skills in a creative and meaningful setting.

Related Science Standards: 1, 2, 4-6, 9, 10
Related Workplace Readiness Standards: 1.2, 1.7, 2.2, 2.5-2.7, 2.9, 3.1-3.5, 3.8, 3.11, 3.15, 4.1-4.3, 4.6, 4.7, 4.11, 5.3, 5.4, 5.7

Distances in the Solar System Model. Astronomers use the measure *astronomical unit (AU)* to represent the distance between the Earth and the sun. In this activity, students construct a paper model of the distances between the planets in our solar system by using the AU and proportional reasoning. As a class, students decide upon a length of paper (perhaps one meter) to represent 1 AU in their model. Referring to a chart that includes the astronomical units for each planet (see below), students first calculate the distance between each planet. Then they measure out their strips of paper to represent the distances between the planets. (They can divide some AUs into 10 smaller strips to represent decimal parts.) Finally, they connect the paper strips and attach a small paper "planet" at the appropriate places.

Remind students that the planets don't usually line up in this manner. Note also that the sizes of the planets are not proportional to each other nor to the distances represented. This model demonstrates the *relative distances between the planets.*

The following chart contains the planets' distances from the sun in astronomical units.



Related Science Standards: 1, 2, 5
Related Workplace Readiness Standards: 2.2, 3.1-3.3, 3.9, 4.2, 5.3, 5.7

Scale Model of Earth/Moon Volumes. This activity gives students the opportunity to demonstrate proportion as they model the relationship between the volume of the Earth and the volume of the moon.

First, the students divide a large lump of clay into 50 balls of equal size. After separating one of the clay balls from the rest of the group, they combine the remaining 49 balls of clay to make one large sphere. In this way, they create a proportional model, or *scale model*, of the moon (one small ball) and the Earth (a large sphere composed of 49 small balls). The ratio of the moon's volume to the Earth's volume is 1:49, the same as it is in real life.

Supporting Educational Research: Adapted from *Project SPICA* (Harvard-Smithsonian Center for Astrophysics).
Related Science Standards: 5, 10
Related Workplace Readiness Standards: 3.2, 3.9, 5.4, 5.7

Walk through the Solar System. This activity gives students an impression of the vast sizes and distances of our solar system, concepts that are difficult even for adults to comprehend. This model of the solar system uses a scale of about 1:6,000,000,000. Each centimeter represents 60,000 kilometers.

Students first choose a familiar object to represent each planet (see chart below). They add clay to the smallest objects to make them relative in size to each other and note the distances from each planet to its neighbor.

Body	Scale Distance (from previous objects) (m)	Scale Size (cm)	Object*
Sun	—	23.0	Ball
Mercury	10	0.08	Pinhead
Venus	8	0.2	Peppercorn
Earth	7	0.2	Peppercorn
Mars	13	0.1	Pinhead
Jupiter	92	2.4	Chestnut
Saturn	108	2.0	Marble
Uranus	240	0.9	Popcorn kernel
Neptune	271	0.8	Popcorn kernel
Pluto	234	0.06	Pinhead

Next, the students embark on a walk through the solar system. This scaled walk spans about 1,000 meters. They count off meter paces (each meter-long pace represents 6,000,000 m) until they reach the location of each planet. Students then take a few minutes to listen to a classmate's report about that planet. Afterward, they continue on their walk, discussing aspects of the solar system, until the last planet.

Remind students of the following:

- The planets are not usually lined up in this manner.
- The planets move at different speeds.
- This is a model that represents relative sizes of planets and distances between the planets.

Supporting Educational Research: Based on "The Thousand Yard Model" by Guy Ottewell (Astronomical Workshop, Furman University, Greenville, SC 29613) as adapted by Kenneth M. Uslabar in "A Stroll through the Solar System." *Science Scope*, October 1993.
Related Science Standards: 1, 2, 5
Related Workplace Readiness Standards: 3.2-3.5, 3.8, 3.9, 5.3, 5.7

Indicator 4: Describe the physical characteristics of the components of the solar system, and compare the Earth to other planets.

LEARNING ACTIVITIES: Grades 5-6

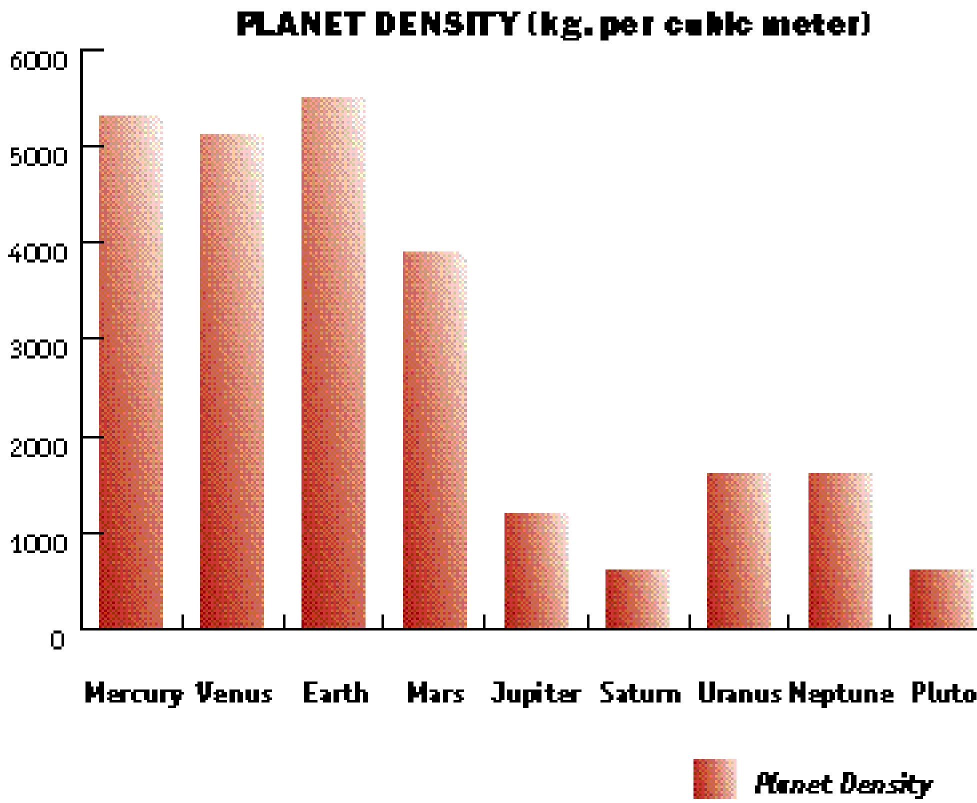
Inner and Outer Planets. In this activity, students explore the large amount of planetary data that has been assembled during the past 20 years. This information is available in print, on CD-ROMs, and on the Internet directly from NASA.

Students organize specific data to contrast the inner and outer planets. If they have begun to study the concept of density, they can use information on the radius and mass of the planets to calculate the gross density of each planet (see chart). (This activity also provides students an opportunity to apply the formula for the volume of a sphere.) After students calculate the planet densities, they create a bar graph of density, with the planets in order according to distance from the sun. They discover the great differences between the inner and outer planets.

Challenge the students to account for this density difference in terms of the gross materials that make up the inner and outer planets (e.g., silica, iron, and hydrogen). The students can obtain and organize information regarding materials and bar charts of the percent composition of silica, iron, and hydrogen. After examining their results, students develop generalizations about the physical characteristics of the planets.

Related Science Standards: 1, 2, 4
Related Workplace Readiness Standards: 1, 2

	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Planet Density	5423.2	5282.52	5489.84	3921.86	1221.35	617.5546	1610.55	1603.637	696.0128
Radius	2.44E+6	6.05E+6	6.39E+6	3.39E+6	7.19E+7	6.04E+07	2.35E+07	2.46E+06	7.00E+06
Mass	3.3E+23	4.9E+24	6E+24	6.4E+23	1.9E+27	5.7E+26	8.8E+25	1E+26	1E+24
Volume	6.1E+19	9.3E+20	1.1E+21	1.6E+20	1.6E+24	9.22E+23	5.5E+22	6.23E+22	1.43E+21



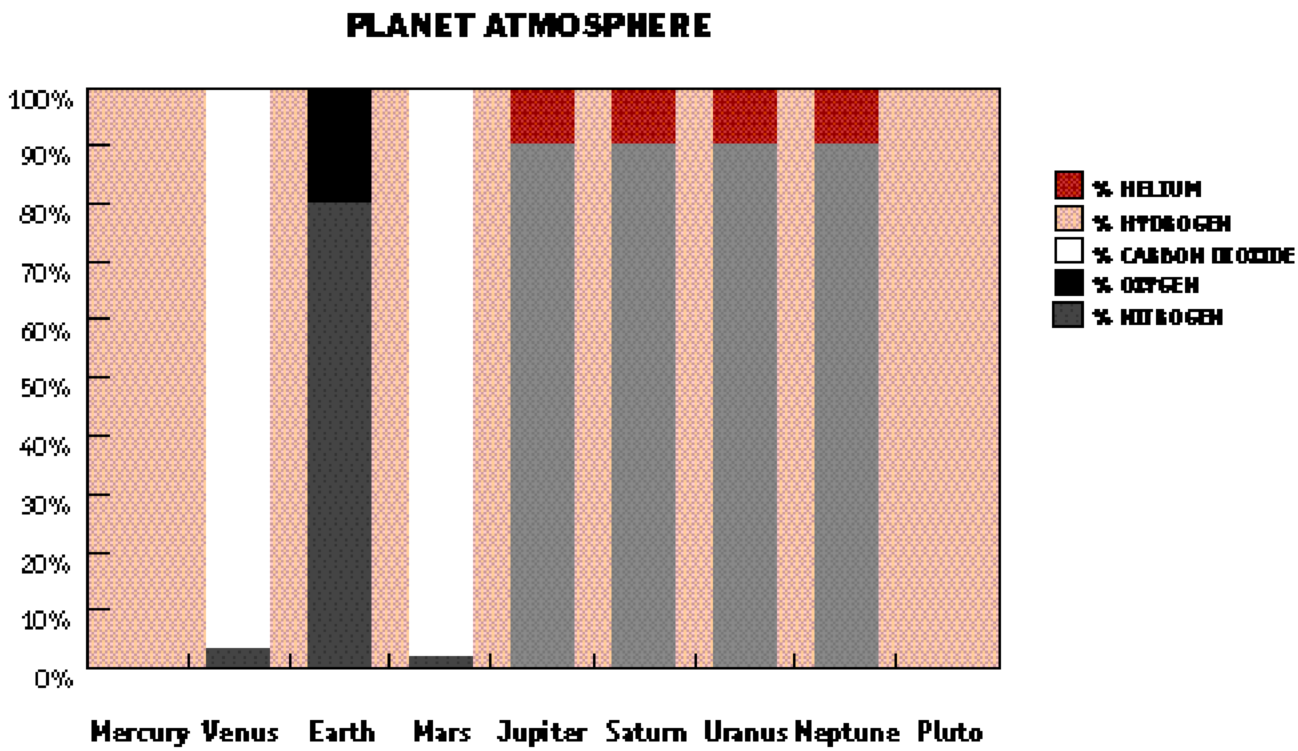
Planet Atmospheres. Students often see artists' representations of planets in popular books and trade books about space. Encourage them to compare these pictures with information about the atmospheres of the planets. For example, they graph the atmospheric pressure and compare their graph to the published illustrations, asking questions such as the following:

- Is the planet surface illuminated by sunlight?
- Is there a definite hard surface on this planet?

Students use information about the percent composition of planet atmospheres to develop a chart of atmospheric compositions. They determine which planets are similar and which are different with respect to atmospheres. Using information about the gases that make up planet atmospheres, students evaluate the realism of artists' renditions of planets and planet surfaces. Students speculate about what it would be like to visit various planets.

Related Science Standards: 1, 3
Related Workplace Readiness Standards: 1, 3

Planet	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Pressure	1E-15	92	1	0.009	100	100	100	100	0.003
%nitrogen		3.5%	78.0%	2.7%					
%oxygen			21.0%						
%carbon dioxide		96.5%		95.0%					
%hydrogen					89.0%	89.0%	89.0%	89.0%	
%helium					11.0%	11.0%	11.0%	11.0%	



Planet Gravities. Weight is the name given to the force of gravity (or "pull of gravity") acting in a direction toward the center of the planet. This force depends on both the mass of the planet and its diameter. For example, a planet having twice the mass of the Earth and the same radius as the Earth would have a surface gravity twice that of the Earth. On the other hand, if a planet has the same mass as the Earth but only one-half the radius, the force of gravity would be four times the force at the Earth's surface (due to the inverse square law of gravity).

From planet to planet, there are extreme differences in surface acceleration due to gravity. In this activity, students conduct a simulation of relative gravitational effects using weighted soda cans. A full soda can is used as the reference object. The weight of a *full* can of soda on the other planets is represented using weighted soda cans. Students add pennies to *empty* soda cans according to the following scheme:

Mercury:	44 pennies	**Saturn:**	114 pennies
Venus:	113 pennies	**Uranus:**	114 pennies
Mars:	44 pennies	**Neptune:**	141 pennies
Jupiter:	301 pennies	**Pluto:**	4 pennies

As students lift and handle the cans, they get a subjective impression of the relative surface gravity on other planets. They weigh these cans and develop a chart of weights and/or relative weights.

Students use the results of these measurements to calculate their own weight on other planets. Challenge students to account for the similarity in surface gravity for planets where the acceleration due to gravity is similar but the planet radii are different.

Alternatively, code the cans (but do not reveal which planet they each represent), then challenge the students to determine which can represents the pull of gravity on which planet.

Related Science Standards: 2, 4, 5
Related Workplace Readiness Standards: 2, 3

LEARNING ACTIVITIES: Grades 7-8

Comparing Distances and Sizes. Students construct scale models of specific relationships between objects within our solar system, such as

- the Earth-moon-sun system (distance and diameter)
- the distance of the planets
- the diameter of the sun compared to that of the planets

Since the models must show relative distance or size, students learn to use a scaling factor. First they decide which relationship they will model. Then, studying the actual numbers involved, they choose a scale appropriate to the model they have selected, the available materials, and the amount of space in which to work. For example, to construct a scaled model of the distances between objects in the solar system, students may choose to make one meter of adding machine tape (or similar paper tape) equal an astronomical unit (AU). This model could even be scaled down further by allowing 20 centimeters of paper tape to represent 1 AU. (The Earth-sun distance is represented by one astronomical unit. Distances between planets are compared to that unit.) A one-meter scaling down would need 40 meters of tape, but a 20-centimeter scaling fits on only 6 meters of tape.

Once students have selected a model they wish to construct and an appropriate scaling factor, they calculate the actual sizes of the features in their models and then plan and construct their models. Materials for the models may include:

- large mural paper
- adding machine tape (or similar paper tape)
- string
- spheres in a variety of sizes
- masking tape
- arts and crafts materials

For the Earth-moon-sun system and the diameter of the sun and the planets, students can create the bodies or find objects that closely represent the dimensions of the bodies in their model. After creating the models, the students explain their models to the class. In this way, students see varied visual representations of the relationships within our solar system.

Related Science Standards: 1, 2, 4, 5, 9
Related Workplace Readiness Standards: 2.2, 2.3, 2.7, 3.1, 3.8, 3.12-3.15, 4.2, 5.3, 5.4, 5.7

Impact Craters. Students investigate the nature of impact craters on the moon by experimenting with *bolides* (colliding objects) to create craters in a bin of flour. First, students determine which properties of an object could affect a crater left upon impact. These factors include

- the mass of the object
- the volume of the object
- the height from which the object is dropped
- the angle of the object's path

By studying pictures of lunar craters, students determine which properties of the crater to measure. They consider the following:

- the diameter of the crater
- the depth of the crater
- the height of the crater wall
- the maximum distance of the ejecta

The students design their experiments, being sure to test only one variable at a time. They place flour in a large bin and cover the flour with a thin layer of cocoa. Then they choose a bolide from a set of balls of varying sizes. They drop the object from a predetermined height and take measurements of the resulting crater and ejecta. They repeat this procedure several times.

After the experiment, students enter their recorded data into a computer database. After combining databases, they analyze the class data and draw conclusions about the relationships between the object's characteristics and the resulting craters.

Related Science Standards: 2, 4, 5, 9, 10
Related Workplace Readiness Standards: 2.2, 2.4, 2.7, 3.1-3.3, 3.6-3.9, 3.12, 4.2, 5.3, 5.4, 5.7

Planet Sorting. Students review a select set of photographs of planets and planet features. These might be

- a collection of actual photographs
- selected 35-mm slides
- selected images on videodiscs or CD-ROMs
- images located and downloaded from specific Web sites

The illustrations used to generate this activity should include photographs of the following:

- *Earth:* blue sky with clouds; blue water with beach; white snow with mountains; a volcano; a hurricane from space; the almost-full Earth; specific locations such as Los Angeles, the Sinai Peninsula, and the Red River (all photos taken from space); Earth's full moon
- *Mercury:* the planet as seen by Mariner 10
- *Venus:* the planet as seen by Mariner 10

- *Mars:* a telescope view of the planet; a volcano and a dry river bed taken by Mariner 9
- *Jupiter:* a full view of the planet; Io and its volcanoes
- *Saturn:* a full view of the planet
- *Pluto:* the most recent image of the planet

Working in teams of two to four, students classify the selected planet images using a classification scheme of their own design. They defend their classification schemes to their classmates. The students return to their work and try another classification scheme. They should look for more specific features such as clouds, water, dust, etc.

Challenge students to answer the following questions:

- What is the white in some photos? the blue? the tan? the red?
- Do different planets have similar features?
- Is there a planet that resembles our moon?
- Is Earth the only planet with hurricanes? the only planet with wind?

Supporting Educational Research: Adapted from an activity published by Astronomy Society of the Pacific.
Related Science Standards: 1, 2, 4, 5, 9
Related Workplace Readiness Standards: 2.2, 2.3, 2.5, 2.6, 3.1-3.8, 3.12-3.14, 4.2, 4.3, 5.7

The Creature Feature. Student teams cooperatively explore an individual planet over a period of time. Establish the following learning centers around the classroom:

- books, periodicals, and NASA materials
- a videotape-library viewing area
- a laser videodisc set-up
- one or two multimedia computers offering access to CD-ROM technology
- Internet access to help students access Web sites such as Nine Planets

Each cooperative team member has a specific task, as outlined below:

- The travel agent produces a travel brochure laced with planet facts but including some stretches of the imagination that extols the virtues of visiting the planet.
- The ship's captain develops a "Captain's Log" that describes the travels to and from his/her planet (truthfully, yet at times imaginatively).
- The biologist "discovers" a creature whose features directly reveal planet facts. (Here imagination has no bounds.)

Each team works together to produce a display representing their creature using posters, sculptures, and/or videos.

A unique aspect of this activity is that the planet name is to be covered up or not used as classmates review each team's reports, brochures, and creatures. A class vote seeks to match planets to the work of the teams. Once all planets have been identified, the products of the research are displayed on hallway bulletin boards and in display cases.

Related Science Standards: 1, 2, 4, 5, 9
Related Workplace Readiness Standards: 2.2, 2.3, 2.5, 2.6, 3.1-3.8, 3.12-3.14, 4.2, 4.3, 5.7

Indicator 5: Explain how naturally occurring events on Earth are related to the positions of the sun, Earth, and moon.

LEARNING ACTIVITIES: Grades 5-6

Modeling Events. Students create models to demonstrate how relationships between the movements of the sun and moon generate not only measures of time but also naturally occurring events.

To begin this investigation, students ask questions based on their observations of the moon and sun. For example, students might ask

- "Why do we have night and day?"
- "Why does it take about a month for the moon to go through all its phases?"
- "Why do the sun and moon appear to rise in the east and set in the west?"
- "What other regularly repeating phenomena relate to the Earth, moon, and sun?"

Next, students choose one question to investigate and select the most appropriate materials:

- Styrofoam™ balls of various sizes (to represent the Earth or the moon)
- skewer sticks (to hold up the balls or to represent the axes)
- toothpicks (to point out one spot on the Earth or moon)
- a lamplight without a shade (to represent the sun)

Manipulating these materials, the students are able to model the phenomena that they have observed. For example, to answer the question about eclipses, students can put a skewer stick through a Styrofoam™ ball to represent the Earth and poke a toothpick in a spot that would indicate the place on Earth where they live. They can demonstrate a total solar eclipse by skewering a smaller sphere and positioning it between the "Earth" and the "sun" so that its shadow falls upon the Earth at the toothpick spot.

By creating these models, the students deepen their understanding of concepts such as length of night and day, naturally occurring moon phases, and the seasons (students can easily simulate the tilt of the Earth's axis).

Related Science Standards: 1, 2, 4, 5, 9
Related Workplace Readiness Standards: 3.1-3.8, 3.12-3.15, 4.2, 4.3, 5.3, 5.4, 5.7

Tides. Tides are the periodic rise and fall of the ocean (sea) level. Of all the celestial bodies, the moon has the greatest influence on the tides. First, students review information about tides using texts and other reference books, CD-ROMs, videodiscs, and videotapes.

Note: There are spectacular videos of Bay of Fundy tides.

Next, students create a paper and plastic-transparency model that displays high and low tides. They take a tidal bulge/moon diagram viewed from far above the Earth's North Pole. The counterclockwise movement of the tidal bulge moving below the moon and the inertial bulge on the opposite side are indicated by an arrow. A second diagram of the Earth, with its azimuthal point of view, is photocopied onto transparency film so that students can place it directly on top of the tidal bulge figure. Both figures, pushpinned down through the Earth's center to a piece of corrugated cardboard, allow for movement. As the students rotate the Earth counterclockwise into and out of the bulges, they clearly see how each day (one spin) consists of two high and two low tides.

After manipulating their models, students describe the role of the moon in generating the ocean tides and explain the different kinds of tides.

Related Science Standards: 1-3
Related Workplace Readiness Standards: 1.1, 2.3, 3.1, 3.2, 3.7, 4.2, 4.3, 4.9, 5.3, 5.4

LEARNING ACTIVITIES: Grades 7-8

A Mathematical Model of Eclipses. Working cooperatively in small groups, students discover concepts relating to eclipses by researching various information sources, such as books and periodicals, videodiscs, CD-ROMs, and Internet sites. They determine the conditions of all types of solar and lunar eclipses. The students relate this information to the modeling they may have done in earlier grades.

Math can reinforce the students' understanding of eclipse phenomena. Using 8.5-by-11-inch graph paper with divisions of 10 units to the inch, students set up three illustrations of eclipse possibilities. The measurements of each radius are listed below:

- Sun: 1.0 inch
- Earth: 0.5 inch
- Moon: 0.1 inch

Tangents touching the sun and moon create *solar eclipses*, while tangents to the Earth and sun result in *lunar eclipses* because the tangents generate umbras and penumbras behind both the moon and the Earth.

Related Science Standards: 1, 2, 4, 5, 9
Related Workplace Readiness Standards: 3.1-3.8, 3.12-3.15, 4.2, 4.3, 5.3, 5.4, 5.7

Tide Tables. Tides are the periodic rise and fall of the ocean (sea) level. Of all the celestial bodies, the moon has the greatest influence on the tides. Students review information about tides using texts and other reference books, CD-ROMs, videodiscs, and videotapes.

Note: There are spectacular videos of Bay of Fundy tides.

Students practice using a tide table, which summarizes daily tidal information. With a sample page from a New Jersey tide table, students identify and record the times for high and low tides on a specific day and for several days in succession. They then graph time of high tide vs. date and answer questions such as the following:

- How long is it from one high tide to the next?
- How long is it from a high tide to the very next low tide?
- Do the equivalent tides occur at the same time every day? If not, approximately how much later? Why?

After completing this exercise, students describe the role of the moon in generating the ocean tides and explain the different kinds of tides.

Related Science Standards: 1-3
Related Workplace Readiness Standards: 1.1, 2.3, 3.1, 3.2, 3.7, 4.2, 4.3, 4.9, 5.3, 5.4

Indicator 6: Describe the technologies used to explore the universe.

LEARNING ACTIVITIES: Grades 5-6

Build Your Own Telescope. Students research the various types of telescopes available, especially those mounted aboard the Hubble Orbiting Telescope. The students display pictures, diagrams, and models of their discoveries.

Based on their research findings, the students construct a simple refractor telescope from mailing tubes, Styrofoam™ trays, and surplus lenses. Obtain mailing tubes that telescope, that is, an inside tube fits in a larger outside tube. Substitutes made from oaktag or some other source are suitable but are not as firm. Another makeshift alternative can be two paper-towel tubes, one slit lengthwise and tightened a little.

Purchase biconvex surplus lenses, one large and one small, from a science supply house or other source. Students follow the steps outlined below to mount the larger lens:

- Cut a short segment from the outside tube to use for tracing.
- Trace three circles (the lens mounting rings) on the Styrofoam tray equal to the tube's inside diameter, then cut these circles out.
- Place the large lens in the center of one of the circles.
- Trace the outline of the lens. Cut this circle out, forming a ring in which the lens can slip.
- Place the lens on the other two disks, and trace again. When cutting, cut the opening a little smaller.
- Place the lens in the center disk, sandwiching it in with the other two disks. Use rubber or contact cement to hold the layers of Styrofoam together.
- Repeat the same procedure to mount the smaller lens.

After both lenses are individually mounted, the students hold the two lens assemblies up and look through both at the same time, moving them back and forth until a distant object comes into focus. They now cut both the inner and outer mailing tubes to 1.5 times that distance.

Related Science Standards: 1, 2, 4, 5, 9
Related Workplace Readiness Standards: 3.1-3.8, 3.12-3.15, 4.2, 4.3, 5.3, 5.4, 5.7

Build Your Own Telescope. The students carefully mount the large lens assembly into one end of the large tube and the small lens assembly into the small tube. They may need to carefully shape and sand the assemblies so they slip into their respective tubes and fit snugly.

The students insert the inside tube into the outside tube so that the lenses are on either end. They aim their refractor telescope at distant objects and focus by pushing or pulling the tubes in or out. Ask them to note whether the object is right side up. Students take the refractor home and look at the moon at night as well as Jupiter and any other celestial object available. Emphasize that they should *never* look at the sun with any telescope.

Note: You may choose to begin the activity by encouraging students to explore the images the lenses form. Guide the students in using the available materials, lenses, mounting circles, and tubes to arrive at an appropriate construction such as that described above. They may modify the construction to solve any problems they encounter as they build their telescope.

Space Shuttle Simulation. Students simulate a space shuttle research mission. First, they build a space shuttle simulator, control panel, and monitors needed for Mission Control using readily available materials, such as

- sheets of plastic and duct tape for the simulator
- cardboard and plastic soda-bottle tops for the control panel
- cardboard boxes, wooden dowels, and laminating film for Mission Control monitors

Next, students draw pictures of the sequence in a shuttle launch on rolls of paper and place them in a cardboard box "TV monitor." They unroll these illustrations during the countdown and launch. The students place video cameras in the shuttle simulator and hook them up to a television monitor in the next room (Mission Control). Similarly, they place a video camera in Mission Control and a television on the shuttle's control panel.

While building the simulator, students explore space research missions on NASA Select television and on the Internet. Together, they choose experiments to conduct both in the simulator and on "Earth," so they can compare results. Students practice communication skills by dividing into two groups separated by a wall: one group gives directions for constructing a building out of manipulatives, while the other group constructs the building from the verbal instructions.

Shuttle crew jobs include the following:

- commander
- pilot
- EVA (extravehicular activity) specialist
- science officers

Mission Control jobs include the following:

- flight director
- crew activities and health director
- EVA specialist
- science officers
- public affairs officer

Supporting Educational Research: Adapted from "More Space in the Classroom," by Betty Fowler, in *Science and Children*. Sept. 1994, pp. 40-41, 45.

Related Science Standards: 1, 4-6, 9, 10
Related Workplace Readiness Standards: 1.2, 1.7, 2.2, 2.5-2.7, 2.9, 3.1-3.9, 3.11-3.15, 4.1-4.3, 4.6, 4.7, 4.9, 4.11, 5.3, 5.4, 5.7

Space Shuttle Simulation. Walkie-talkies are used during the flight. The officers at Mission Control communicate instructions and orders to the astronauts during the flight. Science officers direct experiments conducted on the shuttle. Missions can include activities such as

- constructing a building out of manipulatives
- using a robot arm (a long stick with a grabber)
- using a stereoscopic microscope to examine small objects found in "space"
- investigating worm response to wet and dry surfaces
- measuring heart rates before and after exercise
- any other experiments designed by the students

During the countdown, students play a tape of sound effects simulating ignition and lift-off. After takeoff, the flight director is in control. During the flight, astronauts conduct their experiments, an EVA takes place, astronauts eat a meal, and an "emergency" may take place. After the problem gets resolved, the shuttle lands, and students discuss the results of the shuttle experiments.

In conjunction with this activity, visits might be scheduled to the Buchler Center and/or Liberty Science Center.

LEARNING ACTIVITIES: Grades 7-8

Radio Astronomy. Students explore parts of the radio spectrum using a portable radio tuned to a weak AM radio station. By turning the radio through 360 degrees around all three axes (horizontal, longitudinal, and vertical), students are able to describe the effect of the position of the radio's antenna. They then explore the effects of bringing the radio near sources of "electromagnetic noise." These sources may include light switches as they are switched off and on; fluorescent lights; and computers. Students may use the radio as a detector to find other sources of electromagnetic noise.

Students then study radio astronomy and radio telescopes through photographs, readings, and video resources. They compare visual and radio spectrum images for the same celestial objects. Dramatic images of this type are accessible on the Internet as well as in trade books.

Students explore the nature of interference utilized in very long baseline *radio interferometry* by using visible light. Interference plates that have photographically produced sets of parallel "slits" of varying dimension are commercially available. If the students view a distant light source through these grids, they may observe spectral interference. (These grids are more suitable for this activity than are diffraction gratings because the dimensions of the slits are visible to the naked eye.) Using available computer software, students simulate the production of radio images by combining the slightly different signals received by multiple radio antennas.

With this qualitative experience as background, students search out information that describes the construction and use of radio interferometry antenna arrays.

Related Science Standards: 1-3
Related Workplace Readiness Standards: 1.1, 1.8, 2.3, 3.9, 4.9

Probe Data. There are several long-term, unmanned NASA probes that can be the basis for a sustained study of technology and the collection of information about the solar system. The *Voyager 1* and *Voyager 2* probes are classics in terms of the scope of information collected and of the economy of technology used to collect the information. Another is the more recent *Galileo* interplanetary mission. NASA supports an Internet site for the *Galileo* project (as it does for several other projects). The *Galileo* project is of particular interest because it allows students to explore questions such as the following:

- How big is the probe? (A full-scale silhouette of the probe could be created and mounted in the school during the unit of study focusing on *Galileo*.)
- How was the *Galileo* probe launched?
- What was the overall plan for using the probe to collect information?
- What information was obtained in the first few years of the project?
- What technical problems had to be solved after the launch?
- What instruments are on the probe?
- How is information sent from the probe to the Earth?
- What information was obtained about Jupiter?
- What satellites of Jupiter are to be studied?
- What adjustments in scientific thinking about Jupiter and its satellites have occurred because of data from *Galileo*?

In this activity, students collect information about the properties of several planets and natural satellites. They collect and display photographs from *Galileo's* cameras. They study the technology used to explore the solar system as well as the actual data obtained.

Related Science Standards: 1-4
Related Workplace Readiness Standards: 1, 2, 4

Pictures from Space. Students frequently perceive that the views of the planets and other celestial objects in books, on CD-ROMs, or on videotapes are the results of a roll of film being developed. Through this activity, students learn about the process of optical scanning and how it is used to create planetary images.

To accomplish this task, students obtain a long paper tube (from a roll of wrapping paper, a mailing tube, or a tube constructed from a sheet of oaktag). They trace the tube end on an index card to form a circle slightly larger that the size of the tube. Students cut out the circle and cut that same circle exactly in half. They tape the halves to the end of their tube, leaving a narrow slit of 1-2 mm.

Students now hold the uncovered end of the tube to their eye, close or cover the other eye, and slowly pan around the room or around the school yard. Ask them questions such as

- What do you see?
- Is anything clearly discernible?

Next, the students pan around the room or yard rapidly. Ask them what they now see (or what they think they have seen).

Afterwards, students discuss how images are received from space probes and satellites:

- This information comes in as strings of data.
- Scanning devices within spacecraft imaging systems analyze objects one line at a time.

These light values are converted to radio signals, relayed to receivers on Earth, and then sent to computers that retrieve the original scan one line at a time. The assembled lines form the finished images.

If possible, obtain a sample video of an image developing on a Jet Propulsion Lab screen.

Related Science Standards: 1, 2, 4, 5, 9
Related Workplace Readiness Standards: 3.1-3.8, 3.12-3.15, 4.2, 4.3, 5.3, 5.4, 5.7

Indicator 7: Construct a model that accounts for variation in the length of day and night.

LEARNING ACTIVITIES: Grades 9-12

Sunlight and the Earth. Weather satellites generate imagery by the visible radiation that is reflected back to the planet. A set of four images is not unlike black-and-white photographs that reveal the seasonal variations in *solar altitude* (the angle of the sun above the local horizon) and length of daylight at different latitudes.

Students use visible images of the Earth as viewed by a geostationary satellite in an orbit of 35,800 km. (These images are available from NOAA and other Internet sites.) The images available for this exercise have a subsatellite point located on the equator at 75 degrees west longitude. They also were taken as the sun was setting at the subsatellite point. Therefore, one half of the Earth's disk is in sunlight, and the other half is in darkness. The terminator falls directly at 75 degrees west longitude. The images include latitude, longitude, and the Tropics of Cancer and Capricorn. At the equator, the length of daylight is always 12 hours (ignoring atmospheric optical effects that lengthen daylight). Local time of sunset at the subsatellite point is approximately 6 p.m.

Using these images, students construct a model that allows them to do the following:

- describe the changes in orientation of the Earth's rotational axis relative to the sun's rays over the course of the year
- determine the latitude where the sun is directly overhead (solar altitude of 90 degrees) at local solar noon during the solstices and equinoxes
- estimate the noon solar altitude at any given latitude
- approximate the number of hours of daylight at any latitude
- explain variations in solar altitude and length of daylight in terms of the Earth's motions in space

Related Science Standards: 1, 2, 4, 5, 9
Related Workplace Readiness Standards: 2.2, 2.3, 2.5, 2.6, 3.1-3.8, 3.12-3.15, 4.2, 4.3, 5.3, 5.4, 5.7

Estimating Day and Night. Students apply their developing skills with geometric constructions to develop a geometric model that is related to observations of the length of day and night as well as the height of the sun at local noon. For several days, students use a "shadow stick" to measure the angle of elevation of the sun at local noon. They make these measurements as accurately as possible, and finally graph the angle vs. the date so that they can use a best-fit curve to further reduce measurement errors. For each day during the period when local noon measurements are made, students find newspaper postings of sunrise and sunset.

Students select a specific day. Using the local latitude and the local sun elevation, they construct the following diagram.

1. Construct the circle that represents the Earth.

2. Draw and label the equator.

3. Draw and label the axis of rotation at right angles to the equator.

4. From the center of the circle, draw a ray at the latitude angle. Label this the latitude ray.

5. From a convenient point on the latitude ray, draw a ray at an angle of 90 degrees (the noon altitude angle). Label this the shadow ray.

6. Through the center of the Earth construct a line perpendicular to the shadow ray. Label this line the terminator.

7. Measure the distance from the axis to point L. Construct a circle with this radius.

8. Construct two perpendicular lines through the center of this circle.

9. Measure the distance from point L to the terminator. Label it D.

10. Measure off the distance D from the circle and along one of the diameters in the second circle.

11. Construct a line parallel to the other diameter. Shade in the shadow side of the Earth at the observer's latitude.

12. Measure the central angle in shadow. Use ratios of angles and hours (360 in 24 hours) to find the length of day and night.

13. Compare the result to the published length of day and night.

Related Science Standards: 1-4
Related Workplace Readiness Standards: 1-3

Indicator 8: Evaluate evidence that supports scientific theories of the origin of the universe.

LEARNING ACTIVITIES: Grades 9-12

Big Bang. The term "big bang" has entered the cultural lexicon. In order for students to incorporate the *big bang* concept into their thinking about the origin of the universe, they must develop and coordinate several concepts.

The first concept is that of the *black body radiator*. Students conduct activities and make measurements that enable them to relate the energy output of an object to the temperature produced at a given point away from the object. They use a thermometer with the bulb covered with a square of blackened aluminum foil. They measure the equilibrium temperature produced by 15W, 60W, 100W, and 250W lightbulbs at a fixed distance (such as 50 cm) from the bulbs. A graph of temperature versus energy output in watts will point students toward the idea that the energy output of an object and the related temperature produce a measurable effect away from the object.

To understand the justification for the big bang, students must be able to relate the measurable effects they have observed (in the activity with the lightbulbs, for example) to the idea that all objects radiate photons with an energy proportional to their temperature. A qualitative concept of *photons* and photon sources is one of the conceptual building blocks students must acquire in order to make sense of the big bang. They develop this concept with readings and with video presentations on the properties of photons. As the students learn about the spectrum of a black body radiator, they should be able to sketch such a spectrum. Ask students to describe the nature of objects that can produce black body radiation of various wavelengths or spectra.

Related Science Standards: 1-3
Related Workplace Readiness Standards: 1.1, 1.8, 2.3, 3.9, 4.9

Big Bang. Another issue that students must deal with is the classic Olbers paradox. In the process of coming to grips with the reality that the night sky is not bright in spite of the multitude of stars and galaxies, students use the ideas of the *red shift* and the *expanding universe*.

Through these activities, students learn about several concepts: black body radiation, photon energy, and an expanding universe. At this point, students are presented with the 1965 identification of the cosmic background radiation in the microwave range by New Jersey scientists Arno Penzias and Robert Wilson. Challenge students and guide them in incorporating this phenomenon into an account of the stages in the big bang. The goal in this sequence of experiences is to enable students to use the idea of the big bang as a conceptual model to account for observable phenomena.

Expanding Universe. After students have developed the ability to apply the concept of *spectral shifts* resulting from the relative motion of sources of electromagnetic radiation, they apply the concept to the *cosmological red shift*. The implication of the cosmological red shift with greater spectral shifts for more distant objects is an *expanding universe*.

Students simulate this relationship using the surface of a balloon. They partially inflate a spherical balloon and mark and label 5 to 10 points in random locations on the surface. They consider one of the points as a representation of the solar system, the point from which the cosmological red shift is observed. They measure the diameter of the balloon and the (great circle) distance to each point from the solar system point using a flexible tape measure or a string and ruler. They then inflate the balloon to a larger diameter and repeat the measurements. The students repeat this process again in order to get at least four sets of measurements. Then they graph the distance to each labeled point vs. the diameter of the balloon. Students answer questions such as the following:

Is the increase in distance from the solar system the same for all the points?

Is there a relation between the increase in distance and the original distance?

Remind students that although the balloon is a three-dimensional object, it is the *surface* of the balloon that simulates three-dimensional space in this model.

Related Science Standards: 1, 2, 4
Related Workplace Readiness Standards: 1, 2

Stellar Evolution. Students, while reviewing existing theories of the origin of the universe, realize that *stellar evolution* is an important aspect of the total picture. To follow up on stellar evolution, students access Hubble telescope image sites on the Web and examine images caught by the various instruments located on this orbiting observation platform. Many of these images are used in research articles that discuss the origin of the universe and stellar evolution. Students access and review the written articles as well.

Independent class activities help the students understand how scientists interpret all the information obtained via scientific probes and research.

- They obtain handheld spectroscopes and aim them at various sources of light in a darkened lab classroom. Such light sources include incandescent light, fluorescent light, and spectral tubes of various elements. Students become aware that each element has its own spectral “fingerprint” and that light from stars may be analyzed with this knowledge. Unknown spectral strips from stars are then analyzed for the composition of the source of light.
- They begin to recognize that a star’s color, temperature, and brightness are interrelated. Students graph data of all of these characteristics simultaneously. As the data accumulates, the Hertzsprung-Russell classification scheme emerges.
- Using the Hubble Classification System for galaxies continues the expansion of student understanding. Give students a set of photos of galaxies and urge them to create a way of summarizing their observations of these photos. Students observe type of galaxy and direction of rotation, and then estimate the age of the galaxy.

- Continued research using library resources, computer CD-ROMs, and Internet sites eventually leads the student to the concept of a black hole, a region of space so strong that nothing can escape it.

Students summarize their project into stellar evolution by means of a multimedia presentation, research, models, and/or videos.

Related Science Standards: 1, 2, 4, 5, 9
Related Workplace Readiness Standards: 2.2, 2.3, 2.5, 2.6, 3.1-3.8, 3.12-3.15, 4.2, 4.3, 5.3, 5.4, 5.7

Indicator 9: Analyze benefits generated by the technology of space exploration.

LEARNING ACTIVITIES: Grades 9-12

Cost-Benefit Analysis. The development of a cost-benefit analysis is a complex task. In the case of large science (such as that embodied in NASA projects), the task is complicated because the scientific information obtained is a social good that may not have immediate economic value. When public money is allocated to do science, there is seldom a guarantee of economic benefits. As students study the technologies that have spun off from NASA's large science projects, they will encounter contributions to commercial products as well as general health and safety.

Through reading, debating, and writing, they investigate the formal models for doing cost-benefit analyses. They identify the social and political processes the nation uses to arrive at decisions, especially decisions that are justified on the basis of social good.

Students contact their senators and congressional representatives about NASA funding. Hopefully, they will get up-to-date information from these legislators that will provide a sense of how the nation is currently solving the cost-benefit problem.

Related Science Standards: 1, 2, 4
Related Workplace Readiness Standards: 1, 3

Courtroom Drama. Students develop a courtroom scene: "Benefits generated by the technology used for space exploration: guilty or innocent?!"

Students first review the literature by all means at their disposal, including accessing Web sites. NASA sites, for example, possess a vast array of materials both in print and online. Enough time should be set aside to allow for research at home, in school, or at the library.

As the trial date approaches, students assign themselves roles for the courtroom scenario, such as the following:

- judge
- jury
- witnesses for
- witnesses against

Costuming might even be considered. Students record the proceedings using video cameras. The net result should emphasize the great advances in technology generated by the effort to explore space and the spin-off of these advances into society. The gathered evidence is displayed on hallway bulletin boards or in display cases.

Another role play emphasizes only the advances that spun off into medical technology. Students research various sources to gather information. They then envision an extremely active emergency room (*ER!*), when suddenly all technological advances spurred on by space exploration disappears.

In their research, students select a technology device and find out how space research and development influenced the device's development.

Related Science Standards: 2, 4, 5
Related Workplace Readiness Standards: 2.2, 2.3, 2.5, 2.6, 3.1-3.8, 3.12-3.15, 4.2, 4.3, 5.3, 5.4, 5.7

SCIENCE STANDARD 12

All students will develop an understanding of the environment as a system of interdependent components affected by human activity and natural phenomena.

INTRODUCTION

This standard brings to New Jersey classrooms the intent of the monumental Tbilisi Declaration, findings adopted in 1977 at the world's first intergovernmental, international conference on environmental education. Specifically, this declaration speaks to "utilizing science and technology . . . to prepare the individual for life through an understanding of the major problems of the contemporary world, and the provision of skills and attributes needed to play a productive role towards improving life and protecting the environment."

In addition, such education should "recognize the complexity and interrelated nature of environmental problems and their possible solutions, and should recognize human dependence on, and responsibility for, a healthy environment."

Finally, such education should recognize the complex relationships that exist between the natural and constructed world.

This standard explores the busy crossroads where content in many science standards intersect and interact. Citizens of all ages often forget that they are a part of, and not separate from, a dynamic and shared environment. People forget that daily activities and the maintenance of a specific quality of life can potentially alter environmental balances. We often forget the relationships that exist between people and human health, other living creatures, and these surroundings. This standard affords students the unique opportunity to understand their place in this world—as living creatures, consumers, decision makers, problem solvers, managers, and planners.

DEVELOPMENTAL OVERVIEW

In grades K-4, curious young children are often intrigued by the simple sprouting of an acorn, the coloration of a songbird, the power of moving water, or the decomposition of a rotting log. Interactive and lively examination of the natural world provides "windows" for young students to observe the interdependent relationships and processes that exist between living creatures and the natural resources.

Primary students then learn to recognize their own basic needs for survival and how those needs are met. They can compare their needs with the basic requirements of other living things. They come to recognize human dependence on the natural world. Finally, the students learn to distinguish those resources that can be replenished during their lifetime vs. those that require great quantities of time and a unique set of circumstances in order to be re-created.

By grades 5-8, the middle school years, students are getting to know themselves and their own feelings. They recognize their own potential impact on the environment and its resources, based upon close examination of their personal interests, activities, and preferences. In comparing their own findings with similar feedback collected from their peers, other geographic regions, various societies, or different eras, students will recognize that people have different views toward environmental issues. They learn how to evaluate potential environmental impacts.

Finally, middle school students will examine the components of local and global ecosystems and the effects of those components on the organisms that are dependent upon them.

By grades 9-12, as a result of understanding ecosystems and the needs of people and other living creatures, students can act as managers and planners. They investigate the impact of natural phenomena and physical processes, such as earthquakes, fires, and floods, on the environment of New Jersey and different regions in this country and around the world. They will also be able to apply their understanding of ecosystems to solve other types of environmental problems.

Finally, they will use scientific, economic, and health data to assess the environmental risks and benefits that are associated with various types of human activity. At this age, they should research or be presented with well-rounded simulations, projects, experiments, and debates—those that encourage sound decision making and reflect the results of good vs. poor choices, research, plans, or solutions. Students in these grades will be afforded the valuable opportunity of planning or taking responsible action in real-life situations where they can make a recognizable difference.

DESCRIPTIVE STATEMENT

Creating an awareness of the need to protect and preserve natural resources is a goal of science education. This standard calls for students to develop knowledge of environmental issues, including management of natural resources, production and use of energy, waste management, and the interdependence of ecosystems.

CUMULATIVE PROGRESS INDICATORS

By the end of Grade 4, students

1. Investigate the interdependence of living things and their environment.
2. Explain how meeting human requirements affects the environment.
3. Recognize that natural resources are not always renewable.

Building upon knowledge and skills gained in the preceding grades,
by the end of Grade 8, students

4. Evaluate the impact of personal and societal activities on the local and global environment.
5. Compare and contrast practices that affect the use and management of natural resources.
6. Recognize that individuals and groups may have differing points of view on environmental issues.
7. Analyze the components of various ecosystems and the effects of those components on organisms.

Building upon knowledge and skills gained in the preceding grades,
by the end of Grade 12, students

8. Investigate the impact of natural phenomena and physical processes, such as earthquakes, volcanoes, forest fires, floods, and hurricanes, on the environment of different regions of the United States and the world.
9. Use scientific, economic, and other data to assess environmental risks and benefits associated with human activity.
10. Apply the concept of ecosystems to understand and solve problems regarding environmental issues.

LIST OF LEARNING ACTIVITIES FOR STANDARD 12

GRADES K-4

Indicator 1:

GRADES K-2
Indoor vs. Outdoor Environments
The Four Natural Resources
An Animal and Its Environment

GRADES 3-4
The Web of Life
Interactions in a Habitat
Observing a Tree

Indicator 2:

GRADES K-2
Wastewater
Environmental Themes in Literature

GRADES 3-4
Tree Products
Renewable vs. Nonrenewable Resources
Nonpoint Source Pollution

GRADES K-4
Pizza Makings
Paper Recycling

Indicator 3:

GRADES K-2
Nonrenewable Things
What Grows?

GRADES 3-4
Making Things
Consuming Nonrenewable Resources
Water Cycle
Freshwater

GRADES 5-8

Indicator 4:

GRADES 5-6
Signs of a Healthy Environment
Providing Basic Needs
Transportation and the Environment

GRADES 7-8
Decision Making
Waters of the World
Consumers and the Environment

Indicator 5:

GRADES 5-6
Water Use in the Community
Technology and Culture

GRADES 7-8
Community Planning
Park Visitors
Point Source and Nonpoint Source Pollution

Indicator 6:

GRADES 5-6
Smoking Prevention Advertisement
Advertisements and Wildlife

GRADES 7-8
Points of View
Wildlife Use

GRADES 5-8
Environmental Issues
Class Display Wall

Indicator 7:

GRADES 5-6
Ecosystems of New Jersey

GRADES 5-8
Migratory Shore Birds

GRADES 7-8
Healthy Ecosystem
River Pollutants
Comparing Ecosystems

GRADES 9-12

Indicator 8:

Natural Phenomena
Natural Phenomena in New Jersey

Indicator 9:

Risks and Benefits
Human Health
Identifying Risks

Indicator 10:

Management of Environmental Issues

Indicator 1: Investigate the interdependence of living things and their environment.

LEARNING ACTIVITIES: Grades K-2

Indoor vs. Outdoor Environments. Take the students on a sensory walk of an indoor environment, such as the library or multipurpose room. Ask them if and where they can see, hear, or touch signs of animals, plants, the sun, rocks, soil, air, and water. Take notes on a clipboard.

Walk out to the playground, sit in a circle, observe the surroundings, and repeat the questions. Take notes again. Discuss the similarities and differences between both settings. Discuss how plants and animals use the four elements (air, soil/rock, water, sunlight) and then compare these uses with how people use them. Using a simple chart or diagram, the students compare and contrast their findings from both visits.

Related Science Standard: 6
Related Workplace Readiness Standard: 3

The Four Natural Resources. Students cut out pictures of living things, such as flowers, trees, fungi, and other plants; birds, people, insects, and other animals. They glue each picture to paper or cardboard and make a yarn necklace.

Prior to class, make a necklace for each of the four elements (sun, water, air, soil/rock). Ask four students to each wear one of the necklaces and sit in the center of the classroom. Direct the other students to sit in a circle around the elements. Ask the students, "What things need the sun?" Verify each response and establish connections by instructing students to tautly hold the ends of long "connecting strips" of pre-cut yarn. (Alternately, the students can use a ball of yarn to make the connections.)

When everyone is connected, the element "Water" drops his/her ends. The class will quickly discover what is affected when water quality becomes impaired.

Supporting Educational Research: "Web of Life" in Project *Learning Tree*, pp. 148-50.
Related Science Standard: 6
Related Workplace Readiness Standard: 3

An Animal and Its Environment. Select an animal that is readily seen around the school or in the nearby communities. Create a simple chart where students will, in an ongoing fashion, record their observations of the animal. Categories could include the following:

- food collecting
- shelter needs
- means of travel
- protection measures
- time of day/night most active

After a period of time, discuss how the animal uses its environment to survive and what it contributes to allowing other plants or animals to survive (e.g., a squirrel disperses acorns when it stores them).

Supporting Educational Research: "Squirrel Signs" in Bridges to the Natural World, p. 102.
Related Science Standards: 1, 6, 7
Related Workplace Readiness Standards: 3.1-3.3, 3.7

LEARNING ACTIVITIES: Grades 3-4

The Web of Life. Students brainstorm a list of living, nonliving, and "dead" things that make up an ecosystem or natural area. (For example, woodlands contain dead leaves and logs, grass, rock, etc.) The students then separate these things into three categories: PLANTS, ANIMALS, and OTHER.

Discuss with the students what plants and animals require in order to survive and compare these needs with the things listed in the OTHER category. Make individual labels for all of these things. Mount these labels on the wall in a circle and, using yarn and tacks, work with the students to "link" together all of the interconnections (e.g., sun and grass, water and frog, hawk and mouse).

Alternately, the students form a circle. Hang one label around each student's neck, and instruct the students to pass around a ball of yarn to link themselves together, based upon how the things interact. This process continues until everything is linked. As the students sit quietly, the originating student should begin tugging lightly at the yarn. Anyone who feels the tug should respond with a tug. Ultimately, everyone should feel the tug, demonstrating the interdependence of living and nonliving things in an environment.

Supporting Educational Research: "Web of Life" in *Project Learning Tree*, pp. 148-50.
Related Science Standards: 1, 6, 7
Related Workplace Readiness Standards: 3.1, 3.2, 3.6, 3.7

Interactions in a Habitat. Provide students with pictures of various habitats (or take a series of comparative trips to such areas). Students imagine (or observe) what creatures live in those habitats. On paper, they list the following:

- two physical factors of the area
- two plants
- two animals
- a plant or animal adaptation (e.g., many animals eat the same food but gather it in different ways; plants disperse seeds in different ways)

Next, the students document the types of interactions that they imagine (or observe) taking place in this habitat, including examples of the following types of interactions:

- biological factor on a physical factor (e.g., an animal digging a hole)
- physical factor on a biological factor (e.g., altitude on tree height)
- plant on plant (e.g., a vine growing on a tree)
- animal on plant (e.g., an animal eating a plant)
- plant on animal (e.g., flowers attracting insects)
- animal on animal (e.g., an animal eating another animal)

Afterwards, the students compare findings regarding their habitats.

Supporting Educational Research: "The Eco-Connection" in Bridges to the Natural World, p. 70.
Related Science Standards: 1, 2, 6, 7
Related Workplace Readiness Standard: 3

Observing a Tree. Students adopt one or more local trees for long-term observation. Begin by brainstorming with the class what plants and animals might depend upon that tree. The students visit the tree(s) frequently and look for signs of interdependence, noting all observations and seasonal changes. They work in teams with hand lenses, identification guides or pictures, binoculars, etc. Students document feedback through drawings or descriptions.

Supporting Educational Research: "Trees As Habitats" in *Project Learning Tree*, p. 70.
Related Science Standards: 1-3, 6, 7
Related Workplace Readiness Standard: 3

Indicator 2: Explain how meeting human requirements affects the environment.

LEARNING ACTIVITIES: Grades K-2

Wastewater. Students identify substances and activities within their individual households that can affect water quality, reflecting upon the waste that is usually disposed of down the sink or toilet. Create "sample waste" in the classroom by putting water into a bucket and adding diverse materials such as

- shampoo
- toilet paper
- salad dressing
- gravy (with fat)
- food dye
- detergent
- toothpaste

Mix this up and distribute small paper cups of the mixture to each student. Discuss what *wastewater* is and where it travels to after leaving a home.

Through research, a guest speaker, and/or a video, students learn how wastewater is dealt with in their community. Challenge them to create a simple design of water flow and distribution, including local waterways, filtration plants, and wastewater treatment facilities. Discuss the basic design of a well or septic system, especially if your students or community relies on these. Ask students to design a means to control sink waste at home.

Supporting Educational Research: "My World, My Water and Me."
Related Science Standards: 2, 4, 6, 8
Related Workplace Readiness Standards: 3.2, 3.6, 3.7, 5.1

Environmental Themes in Literature. Use children's literature to discuss cause-and-effect relationships between the activities of people and the effects (positive and negative) on the environment and/or natural resources. Ask students to identify the various issues described in the stories, and challenge them to create and design alternative solutions. Sample stories include the following:

- *The Wump World* by Bill Peet
- *The Lorax* by Dr. Seuss
- *The Giving Tree* by Shel Silverstein
- *The Kapok Tree* by Lynne Cherry
- *Brother Eagle*, *Sister Sky* by Susan Jefferies

Supporting Educational Research: *Grade One, Day One Curriculum*
(Environmental and Occupational Health Sciences Institute).
Related Science Standards: 1, 3, 6, 7
Related Workplace Readiness Standard: 3.8

LEARNING ACTIVITIES: Grades K-4

Pizza Makings. Create a "pizza with everything on it" in the classroom by using an old bedsheet and other materials to represent various toppings. Beginning with the crust, the students trace each ingredient back to the four basic elements (sun, water, soil/rock, air) before each ingredient is layered onto the pizza.

Afterwards, discuss what people need in order to survive. Focusing on food and water, challenge the students to think of food items or drinks that do not require any of the four elements for their existence.

Older students can select one food item and research how its production, packaging, transportation, distribution, consumption, and waste—the many interactions that it has on the environment.

Paper Recycling. Students collect, save, and weigh the class's discarded paper, for one week. Discuss or design ways in which this weight/volume could be reduced, and challenge the students to adopt these new practices in the classroom.

For a second week, the students again collect, save, and weigh the class's discarded paper. Discuss any changes, if any, that took place.

As extension activities, students research the production of new paper and the production of recycled paper. Then they make recycled paper in the classroom.

Supporting Educational Research: *Project Learning Tree*
Ranger Rick's *Nature Scope* Series (National Wildlife Federation).
Grade One Curriculum (Environmental and Occupational Health Sciences Institute).
Related Science Standards: 1-4
Related Workplace Readiness Standards: 3.3, 3.5, 3.7

LEARNING ACTIVITIES: Grades 3-4

Tree Products. The students brainstorm the many products that are made of wood or are otherwise derived from trees. Challenge them to research the topic and then bring in as many of these products as possible. In the classroom, the students label each product as follows:

- #1, if it was produced from tree sap, gum, or resin (e.g., glues, maple syrup, soaps, rubber)
- #2, if it is made of wood (e.g., pencil, toothpick, chair)
- #3, if it is a fruit or nut (e.g., apples, walnuts, cider)
- #4, if it is an extract from the leaves (e.g., tea, lotion)

Review the diversity of products that are derived from trees. As an extension activity, students can do additional research on current conservation and management practices for specific tree species, or historic or cultural uses of trees.

Supporting Educational Research: "We All Need Trees" in *Project Learning Tree*, pp. 39-42.
Related Science Standards: 1, 3, 4, 7
Related Workplace Readiness Standards: 3.2, 3.7, 3.9

Renewable vs. Nonrenewable Resources. Students create a master list of what they think they need to live comfortably. The class discusses the list, labeling each item as

- "Essential for Current Lifestyle"
- "Maintains Current Lifestyle"
- "Luxury"

Through discussion or research, the students trace several key items back to the natural resources from which they were made. For example, a lead pencil requires graphite, wood, metals (paint), rubber (eraser). Discuss the terms *renewable* and *nonrenewable* and provide examples of each type of natural resource. Ask students to identify which items on the master list require renewable resources (label as "R"), nonrenewable resources ("N"), or both ("B") in order to be made or produced.

As an extension activity, students conduct the same activity as Native Americans, Colonial Americans, or Americans in the earlier part of this century.

Supporting Educational Research: "A Look At Lifestyles" in *Project Learning Tree*, p. 354.
Related Science Standards: 1, 3, 6, 8, 9
Related Workplace Readiness Standards: 3.3, 3.5, 3.9

Nonpoint Source Pollution. Students learn that *nonpoint source pollution* occurs when materials such as fertilizers, used motor oil, pesticides, sediments, road salts, and litter enter a local waterway, primarily through rain and runoff. This type of pollution results from human activities.

Each student writes a short story or scenario about one of the pollutants listed above. Place a string on the floor. Students volunteer to stand next to the string, holding an index card. Each volunteer holds a small paper cup with a different color of water in it (Kool-Aid®). Cut the narrow top off an empty plastic milk jug and partially fill it with clear water. Simulating a local waterway/watershed, walk along the string with the jug. Each student reads his/her card and then dumps the contents of the cup into the jug.

Afterwards, discuss potential impacts of nonpoint source pollution, ways that nature can sometimes reduce or break down the amount of pollutants in water, and ways in which people can prevent water pollution. Offer students a drink of the colored water in the jug if Kool-Aid was used. (*Do not drink* the water if food coloring was used!)

Supporting Educational Research: *Project WET*.
Related Science Standards: 1-3, 8, 9
Related Workplace Readiness Standards: 3.3, 3.6, 3.9

Indicator 3: Recognize that natural resources are not always renewable.

LEARNING ACTIVITIES: Grades K-2

Nonrenewable Things. Give each student a piece of bread or cookie. After it's chewed and swallowed, ask the students to make the food item whole again. Discuss why this is not possible. Some materials can be created during the lifetime of an average person, while other items cannot be recreated due to length of time, specific processes, and other factors.

Related Science Standards: 1-3, 8
Related Workplace Readiness Standards: 3.3, 3.6, 3.7

What Grows? Discuss how a seed is a part of a plant and a bottle cap is part of a soda bottle. In a controlled experiment, students plant both of these items and provide them with necessary sunlight and water. After the seed germinates, the students discuss why the seed became a new sprout but why the bottle top did not become a new bottle.

Related Science Standards: 1, 2, 6, 7
Related Workplace Readiness Standards: 3.3, 3.7

LEARNING ACTIVITIES: Grades 3-4

Making Things. Students select a favorite object (e.g., a tennis racket, pair of jeans, a stuffed animal). They list all of the materials that make up the object. Discuss whether the materials are man-made or from the Earth. Explain that all of the materials require natural resources in order to be created. For each of the components making up the favorite object, trace the material back to the Earth's natural resources. Identify each of these resources and discuss with the students which can be replaced or recycled during their lifetime, and which cannot. Discuss the meanings of the terms *renewable* and *nonrenewable*.

As an extension activity, the students research which natural resources are used to produce their community's power/energy.

Supporting Educational Research: "A Few of My Favorite Things" in *Project Learning Tree*, p. 48.
Healthy Environment, Healthy Me, p. 36.
Related Science Standards: 1, 6, 7, 8
Related Workplace Readiness Standards: 3.3, 3.7-3.9

Consuming Nonrenewable Resources. After the class completes the "Making Things" activity, fill a large container with popcorn. Prepare slips of paper (one per student) marked "First Generation," "Second Generation," or "Third Generation." For every group of seven students, there should be one "First Generation" slip, two "Second Generation" slips, and four "Third Generation" slips.

Put the slips into a hat. Each student takes a slip of paper and a small, empty paper bag. Explain that the popcorn represents the world's supply of nonrenewable resources (list some examples). The "First Generation" students place two ample handfuls of popcorn into their bags while the other students watch. Repeat this for the "Second Generation" students and then for the "Third Generation" students. Discuss what happened by the third generation and what would be left for the next (fourth) generation. Discuss the management and long-term considerations of the Earth's nonrenewable natural resources.

Supporting Educational Research: "Renewable or Not?" in *Project Learning Tree*, pp. 43-46.
Related Science Standards: 1-3, 5, 6, 8
Related Workplace Readiness Standards: 3.7, 3.9, 3.10, 4.2, 4.3, 4.7

Water Cycle. In this activity, students list the components of the water cycle (e.g., lake, ocean, stream, groundwater) as well as ways in which water moves (e.g., precipitation, condensation, evaporation). The students draw a mural of the water cycle and/or act it out. Discuss the role of the sun and the age of water, and how water (a renewable resource) is "recycled/reused," since the Earth is a closed system.

As an extension activity, students research how water is used at home or by various industries. Challenge them to design ways to conserve water at home or at school.

Supporting Educational Research: "The Hydrologic Cycle" in *Grade Four Curriculum*, p. 36 (Environmental and Occupational Health Sciences Institute).
Related Science Standards: 1, 2, 10
Related Workplace Readiness Standards: 3.2, 3.5, 3.8

Freshwater. Although water is renewable, freshwater is limited, and conservation and management are important. Show students a liter of water, and tell them that this amount represents all of the water on the Earth. Pour 30 ml of this water into a 100-ml graduated cylinder, explaining that this amount represents freshwater (about 3% of the total). Pour salt into the remaining 97% to represent the saltwater found in the oceans.

Going back to the cylinder, explain that almost 80% of the Earth's freshwater is frozen in ice caps and glaciers. Pour 6 ml of the freshwater into a dish, and place the cylinder and remaining water into a freezer (or closet). Going back to the water in the dish, only 1.5 ml of this is surface water while the rest is groundwater. Use an eyedropper to remove a single drop of fresh, surface water. This amount represents the percentage of fresh water available for use and consumption by living things.

Supporting Educational Research: "A Drop in the Bucket" in *Project WET*, p. 158.
Related Science Standards: 1-3, 5
Related Workplace Readiness Standards: 3.7-3.9

Indicator 4: Evaluate the impact of personal and societal activities on the local and global environment.

LEARNING ACTIVITIES: Grades 5-6

Signs of a Healthy Environment. In this activity, students recognize critical "indicators" of a healthy environment. First, discuss indicators such as the following:

- clean air and water
- fertile soil
- abundance and diversity of indigenous plants and animals
- reproduction of life forms
- evidence of the recycling of nutrients

The class splits into field teams. Each team carries out an experiment or exercise in a local outdoor setting where one or more of the above environmental factors are present. Each activity is designed to reveal something about the relative health of the local environment, as suggested by the condition of that factor. For example, soil tests indicating favorable soil nutrients suggest that healthy populations of plants and animals probably live off of that soil. Students can then verify the actual presence of these plants and animals.

Afterwards, students discuss the impact (positive or negative) that one or more personal and societal activities may have on the various environmental factors studied in this activity.

Related Science Standards: 1, 2, 7
Related Workplace Readiness Standard: 2

Providing Basic Needs. Students first discuss the basic needs of humans (e.g., water, air, shelter, food, open space). Obtain a piece of rope long enough to form a circle for the entire group to step into and stand comfortably, then place the rope on the ground. Ask the students to step inside the circle, then instruct them to step outside the circle. Explain to the group that part of their environment has been impacted due to development. Reduce the size of the rope, and ask the group to again enter the space provided inside the circle. Decrease the size of the circle using various issues that pertain to the loss of habitat or of a basic need (e.g., water pollution, roadways, litter).

Ask the group to explain what happened as they lost a portion of area or of that resource. Discuss how both plant and animal species in this area might adapt and deal with the changing situation. What are their options? Challenge the group to identify potential solutions that would prevent such losses, or have them bring in newspaper articles that represent this occurrence.

Related Science Standards: 1, 2, 6
Related Workplace Readiness Standard: 2

Transportation and the Environment. In this activity, students explore driving and transportation options. Small groups of students walk to busy intersections near the school where they can safely observe traffic. For about 30 minutes, they count the number of cars that pass by in one direction, and record the number of persons in the car.

Back in the classroom, the students calculate whether air pollution would increase or decrease if people traveled by bus instead of car. They use the following estimates:

- One bus carries 50 persons.
- One bus causes the same amount of air pollution as five cars.

The students discuss why bus transportation might not be favored. They plan and conduct a survey of driving patterns in their school or surrounding community. As an extension activity, they research public transportation patterns in other areas, and design a school or community transportation plan.

Supporting Educational Research: Adapted from "Car Count" in
Healthy Environment, Healthy Me—Exploring Environmental Issues, p. 52
(Environmental and Occupational Health Sciences Institute).
Related Science Standards: 1-5
Related Workplace Readiness Standards: 2-5

LEARNING ACTIVITIES: Grades 7-8

Decision Making. In this simulation activity, students role-play various interest groups who make decisions based on the facts presented.

> *Sample Situation:* A person who owns a lot in a shopping district wants to put a car business on the lot. The city requires that the lot conforms to city codes and guidelines. Neighbors do not want noise and visual pollution. Environmental groups want to protect the existing natural features.

Create a list of needed requirements for a proposal. The class then divides into groups, each of which develops a proposal that addresses the concerns of all parties. Each group presents their proposal to another group of students representing the City Council. The City Council makes the final decision and presents their rationale.

Supporting Educational Research: Democracy In Action" in *Project Learning Tree*,
pp. 196-200.
Related Science Standards: 1-4
Related Workplace Readiness Standards: 2-4

Waters of the World. In this activity, students imagine water flowing from their location to all parts of the world and prepare a narrative. They identify specific water cycle components, such as oceans, rivers, and the atmosphere, and emphasize the interrelatedness of the world's waters.

Next, the students take a field trip to a local waterway and measure the flow rate of a local stream, canal, or river (or research this information). They compare their results to the amount taken locally from the same source by the community water utility. Discuss with the students how the water is used and how it is returned to the environment. Emphasize that this movement occurs over and over again. For example, water utilities take 75 million gallons of water from the Delaware and Raritan Canal each day, providing approximately 140 gallons per day per person to the area served. The canal is 6 feet deep and 42 feet wide. The students calculate the flow (in gallons per day) by identifying the length of the section and the time it takes for a drop of water to flow through that section.

Supporting Educational Research: "Water Wings" in Aquatic *Project Wild*, p. 4.
Related Science Standards: 2, 3, 5, 10
Related Workplace Readiness Standards: 2-5

Consumers and the Environment. Divide the class into smaller groups with the following assignment: to plan a party for 20 middle school students with a budget of only $50.00. You need to choose a location for the party and figure ways to obtain enough food, drinks, plates, utensils, party decorations, music and any other necessary supplies for $50.00 or less. In addition, all decisions must take into account its impact(s) on the environment. Each group will present their purchases to the class. Allow time for research and price gathering.

Supporting Educational Research: "Talkin' Trash, An Earth Saver Activity" in *Environmental Decision Making for Middle School Students* (Environmental and Occupational Health Sciences Institute).
Related Science Standards: 2, 5
Related Workplace Readiness Standards: 2-4

Indicator 5: Compare and contrast practices that affect the use and management of natural resources.

LEARNING ACTIVITIES: Grades 5-6

Water Use in the Community. Through a simulation activity and research, students analyze water use and management. First, students use the yellow pages of a phone book to identify various ways that water is used in their community.

Afterwards, the class goes outdoors with a large bucket, water, and various sizes of sponges. Through an organized relay race, students simulate a growing population and the various volumes of water needed by homes, schools, industries, restaurants, etc. Water being returned to the bucket represents movement in the water cycle. Students can use food coloring to mark "sediments" from runoff or "leakage" from a pipe or storage container. Students can research the amount of water actually used in a growing community and then make realistic calculations about water use.

Supporting Educational Research: "Common Water" in *Project WET*, p. 232.
Related Science Standards: 2, 3, 5
Related Workplace Readiness Standards: 2-5

Technology and Culture. Students research and compare the technologies of three different cultures in United States history to determine their relative impacts on the environment:

- Lenni-Lenape (circa 1000)
- Colonial America (circa 1800)
- New Jersey (1990s)

Students review the impacts of technologies related to shelter construction, food gathering and preparation, and heat and warmth. They compare the technologies in terms of the following:

- resources used
- energy consumed
- pollution created
- significant alterations to the land

As an extension activity, students review contemporary technologies and suggest alternatives that might be more environmentally "friendly" than existing ones.

Related Science Standards: 2-4
Related Workplace Readiness Standards: 2, 3

LEARNING ACTIVITIES: Grades 7-8

Community Planning. In this activity, small groups of students work together to lay out and develop a working community around a body of water. First, draw a picture of a lake (with incoming and outgoing streams), and give one copy to each group of students. Somewhere on their paper the students draw the following:

- a strip mall (containing a theater, food mart, dry cleaners, restaurant)
- a parking lot
- a gas station
- an apartment building
- a housing development
- a school
- a protected wetlands area
- a bleach factory
- a print shop
- a farm feed lot
- a corn field
- a fire house
- offices
- roads where needed

The class compares and discusses the communities. Attach the incoming and outgoing streams together, and ask the students if they would make any changes, knowing that their decisions can impact other communities.

Supporting Educational Research: "Dragonfly Pond" in *Project Aquatic WILD*, pp. 154-59.
Related Science Standards: 2, 3, 5, 6
Related Workplace Readiness Standards: 2, 3

Park Visitors. Students share their experiences with any national parks that they have visited. Using their combined experiences, they design a national park on the chalkboard, describing its natural features, topography and acreage, as well as recreational needs and uses of the property. Discuss why parks are usually created and why they are so popular. Ask students to identify typical park expenditures and potential sources of incoming funds.

Visits to national parks have increased during the last 50 years, presenting parks with many issues. The class divides into three groups, and each group selects an issue such as

- traffic, congestion, and not enough parking
- increased illegal activities, such as vandalism, theft, rapes, etc.
- increased demands for high-impact recreation (e.g., off-road vehicles, mountain bikes, snow mobiles)

After researching the issue, the students share their solutions and discuss how parks might pay for additional costs. They discuss park policies regarding research, timber and wildlife management, commercialism, etc., and identify management guidelines for a long-term plan.

Supporting Educational Research:
"Loving It Too Much" in *Project Learning Tree*, pp. 108-113.
Related Science Standards: 1-3, 5, 6
Related Workplace Readiness Standard: 2

Point Source and Nonpoint Source Pollution. To identify the various land uses in their community, students obtain local maps, such as road maps, aerial photographs, and topography maps. (A phone book may be helpful.) They note all surface water bodies and groundwater in their area. Students discuss potential point and nonpoint sources of water pollution that can result from these land uses, including the following:

- erosion
- air emissions
- discharges
- agricultural runoff

The students monitor the water quality of a local waterway by collecting samples and conducting tests on a regular basis. In this way, they document the impact of development and accompanying pollution.

Related Science Standards: 1, 2, 4
Related Workplace Readiness Standards: 2, 3

Indicator 6: Recognize that individuals and groups may have differing points of view on environmental issues.

LEARNING ACTIVITIES: Grades 5-6

Smoking Prevention Advertisement. Students find and share ads for various brands of cigarettes. They discuss the images portrayed by the ads and what attracts young people to smoking. Working in small groups, they create a smoking prevention ad for either radio or the print medium, incorporating at least one fact they learned about smoking (e.g., health effects or secondhand smoke hazards). Afterwards, the groups share their ads with the class.

Students can create similar ads for issues such as littering, water conservation, energy conservation, and waste reduction.

Supporting Educational Research: Adapted from "Enviro-ad for Health" in *Healthy Environment, Healthy Me—Exploring Air Pollution Issues*, p. 78 (Environmental and Occupational Health Sciences Institute).
Related Science Standards: 1-3, 6
Related Workplace Readiness Standard: 3

Advertisements and Wildlife. Students brainstorm and discuss their feelings/impressions about specific wildlife (e.g., an eagle, a wolf, a deer, an owl, a turkey). They discuss slang phrases such as "you sly fox!" and "a wise old owl." Each student brings in or describes one or more advertisements that use a form of wildlife or the natural environment (e.g., a pristine wooded area or a canyon) as part of the ad. The students discuss answers to the following questions:

- What image was used?
- What is the advertiser's purpose?
- Does the wildlife or natural area used have a direct relationship to the product?
- What feelings and/or stereotypes are elicited?
- Is the wildlife or natural area depicted realistically?
- Does this portrayal encourage or discourage increased environmental awareness?

Afterwards, the students create ads that use wildlife and the environment and describe to their classmates the intent of their design.

Supporting Educational Research: Adapted from "Does Wildlife Sell Cigarettes?" in *Project WILD*, pp. 232-33.
Related Science Standards: 1-3, 6
Related Workplace Readiness Standard: 3

LEARNING ACTIVITIES: Grades 5-8

Environmental Issues. Prepare at least five environmental statements that can evoke controversy and can be responded to in varying degrees between "Strongly Agree" and "Strongly Disagree." Examples include the following statements:

- "Humans have a responsibility to protect *all* life-forms on Earth."
- "Individuals should be able to use their own land in whatever way they see fit."

Using chalk, string, or tape, create a scale of 1 to 10 on the floor, with the numbers having at least a yard between them. Designate one end as "Strongly Agree" and the other end as "Strongly Disagree." After each statement is read, ask the students to find a place on the line that describes their opinion on the statement.

When all the students are standing on the line, half of the students (those standing at the left, for example) walk to the other end of the line to face a partner having a different point of view. Ask each student to listen to, and memorize, the opinion of his/her partner. Students then share their partner's opinion with the class and state whether their own feelings changed after listening to the other opinion.

Supporting Educational Research:
Adapted from "Values on the Line" in Project Learning Tree, pp. 58-60.
Related Science Standards: 1-4
Related Workplace Readiness Standards: 2, 3

Class Display Wall. The class creates a display in the classroom that collectively represents each student's perspective on an environmental issue. Items mounted on the wall could include

- quotes
- articles
- drawings
- poetry
- photography
- cartoons

Related Science Standards: 1, 3, 4
Related Workplace Readiness Standard: 2

LEARNING ACTIVITIES: Grades 7-8

Points of View. Individually or in small groups, students select a local or global environmental issue that has various perspectives. They research the various points of view, e.g., environmentalists rallying for the preservation of a wildlife species' habitat vs. others arguing for jobs that would be lost if development does not occur.

The students present these perspectives to the rest of the class and generate recommendations on how to resolve the controversial issue. In a class discussion, the students analyze

- whether these opinions are informed
- whether these opinions are addressed through their recommendations

Related Science Standards: 1-3
Related Workplace Readiness Standards: 2, 3

Wildlife Use. Students brainstorm a list of ways in which wildlife is used. They then volunteer to represent one side or another on the following debate topic: "Wildlife populations should be managed by humans or left to nature." Each team researches and prepares arguments regarding its position and appoints a captain to present opening remarks. The captains then select one member of their team to "face off." First one person, then the other, is given one minute to present his/her point of view. The remaining students in the class judge and award a point to the team with the best argument presented, per pair of students.

After the debate, students summarize their own perspectives on consumptive and nonconsumptive uses of wildlife.

Supporting Educational Research:
Adapted from "Pro and Con: Consumptive and Non- consumptive Uses of Wildlife" in *Project WILD*, p. 250.
Related Science Standards: 1-3, 6
Related Workplace Readiness Standard: 3

Indicator 7: Analyze the components of various ecosystems and the effects of those components on organisms.

LEARNING ACTIVITIES: Grades 5-6

Ecosystems of New Jersey. Students identify at least three types of ecosystems that exist in New Jersey (e.g., fields, woodlands, and freshwater wetlands). For each ecosystem, they brainstorm and list various features of that ecosystem, such as its flora, fauna, seasonal changes, topography, and ground cover.

Each student selects an ecosystem and then "invents" an imaginary animal to live there, identifying its sex and describing its adaptations to the environment, including its

- food source(s)
- shelter
- behavioral patterns
- protection against enemies
- means of travel

The students draw a picture of their creature. In a presentation to their classmates, the students describe their creature as well as its surroundings and adaptations.

Supporting Educational Research: Adapted from "Adaptation Artistry" in *Project WILD*, pp. 114-15.
Related Science Standards: 1, 2, 6, 7
Related Workplace Readiness Standards: 3, 4

LEARNING ACTIVITIES: Grades 5-8

Migratory Shore Birds. Students research a species of migratory shorebird, songbird, or raptor, focusing on its travel between nesting habitats and wintering grounds, and the hazards along the way. In their report, they should do the following:

- List the limiting factors affecting populations of their bird species.
- Predict the effects of such limiting factors.
- Describe the effects of habitat loss and degradation on the population of their bird species.
- Make inferences regarding the importance of a suitable habitat for their migratory bird species.

Supporting Educational Research: Adapted from "Migration Headache" in *Project WILD*, pp. 94-98.
Related Science Standards: 1, 5-7
Related Workplace Readiness Standards: 2-3

LEARNING ACTIVITIES: Grades 7-8

Healthy Ecosystem. After reviewing the conditions necessary for a healthy ecosystem, students describe what could happen to an ecosystem if these conditions are altered or eliminated. They discuss what clues they would look for to determine if an ecosystem is healthy or not. Working in small groups, students select a macroinvertebrate species to research. They prepare a report about their critter and present the report to the class.

After the presentations, the class compares each organism's tolerance of different stream conditions.

Supporting Educational Research: Adapted from "Macro-Invertebrate Mayhem" in *Project WET*, p. 322.
Related Science Standards: 1, 2, 6,
Related Workplace Readiness Standards: 2, 3

River Pollutants. Present the class with a hypothetical river and examples of chemical, thermal, organic, and ecological pollution that might impact it. After researching major sources of these types of pollutants, the students make inferences regarding the potential effects of these pollutants on aquatic plants and animals. They investigate the laws, policies, and practices already in place in New Jersey that help to protect the integrity of aquatic ecosystems. Finally, the students make recommendations regarding actions that can be taken to protect water quality and prevent, reduce, or otherwise control the pollutant that they researched.

Supporting Educational Research: Adapted from "Deadly Waters" in *Project Aquatic WILD*, pp. 146-50.
Related Science Standards: 2, 4, 5
Related Workplace Readiness Standards: 2, 3

Comparing Ecosystems. Students identify the types of ecosystems that exist in New Jersey (e.g., fields, woodlands, and freshwater wetlands). For each ecosystem, they brainstorm and list various features of that ecosystem, such as its flora, fauna, seasonal changes, topography, and ground cover.

Next, each student selects two similar plants (e.g., wildflowers) or animals (e.g., songbirds) that live in two different ecosystems. After researching each species, the students compare and contrast their specific adaptations and discuss how each species meets its basic needs.

Related Science Standards: 1, 2, 6, 7
Related Workplace Readiness Standards: 3, 4

Indicator 8: Investigate the impact of natural phenomena and physical processes, such as earthquakes, volcanoes, forest fires, floods, and hurricanes, on the environment of different regions of the United States and the world.

LEARNING ACTIVITIES: Grades 9-12

Natural Phenomena. Students brainstorm and develop a comprehensive list of natural phenomena. Working in small groups, they select and investigate a specific event. If possible, their research should focus on three different areas where the event occurs—areas that vary according to population, geographic location, and land use. Their findings should comprehensively describe the phenomenon and include the following:

- characteristics and/or causes of the natural phenomena
- warning signals that scientists have developed
- protective measures (if any) that have been taken

Each group presents its findings to the class and identifies any beneficial outcomes of these occurrences. Students discuss why such phenomena are often disastrous to humans, and how such disasters might be prevented or avoided.

Related Science Standards: 2, 9, 10
Related Workplace Readiness Standards: 2, 3

Natural Phenomena in New Jersey. Students investigate natural phenomena that significantly impact New Jersey, such as coastal storms, Passaic River flooding, drought, and forest fires in the Pinelands. They research various sources, including the following:

- historical accounts and impacts
- current regulations
- local ordinances and other preventive measures
- varying opinions of interested parties regarding the phenomena

Afterwards, the students present their findings to the class.

Related Science Standards: 2, 3, 9, 10
Related Workplace Readiness Standards: 2, 3

Indicator 9: Use scientific, economic, and other data to assess environmental risks and benefits associated with human activity.

LEARNING ACTIVITIES: Grades 9-12

Risks and Benefits. Students list and describe their favorite activities that involve a level of personal risk. For each activity, they identify their personal benefits in a column labeled "Benefits." In another column labeled "Risks and Costs," they list all financial costs, environmental impacts, and potential health risks that are related to the activity. Finally, they add other potential environmental, financial, and health benefits to the "Benefits" column.

When the students have each completed these lists for at least four of their favorite activities, they prioritize them according to which they feel have the most benefits and least risks. For example, driving a van with three families from home to the football game may have the benefits and risks/costs outlined below:

Benefits

- vanpooling
- social/fun/recreational
- support provided for team

Risks and Costs

- potential for an accident while in vehicle
- air pollution caused by van
- cost to get into game

Related Science Standards: 2, 4, 5, 8, 9
Related Workplace Readiness Standards: 1-3

Human Health. In small groups or as a class, students generate a list of environmental issues that have potential impacts on human health. Examples include the following:

- outdoor air pollution (ozone or particulate matter)
- indoor air pollution or smoke
- radon
- radiation exposure
- contaminated drinking water
- potentially harmful chemicals in consumer products

- pesticide usage
- oil spills and landfills
- hazardous waste spills
- droughts
- hunting

Each student ranks each issues as *High Risk (H), Medium Risk (M), or Low Risk (L)*. Tally everyone's feedback.

Students select issue and conduct research regarding scientific and economic factors, health and environmental impacts, as well as preventive and control measures that are related to each issue. After they present their reports to the class, they revisit their personal and group rankings.

Supporting Educational Research: Adapted from "What's the Risk?" in *Environmental Science: How The World Works and Your Place In It*, by Jane Person.
Related Science Standards: 1, 2, 8-10
Related Workplace Readiness Standards: 1.3, 1.5

Identifying Risks. Students identify risks that historically had great impacts on human health but have since been resolved. Examples include the following risks:

- water-borne diseases reduced by water purification
- car injuries reduced by seat belts
- bicycle injuries reduced by helmets

Students research the scientific data concerning the problem, how it was reduced, and the resulting benefits.

Related Science Standards: 2-5
Related Workplace Readiness Standards: 1.5, 2.2

Indicator 10: Apply the concept of ecosystems to understand and solve problems regarding environmental issues.

LEARNING ACTIVITIES: Grades 9-12

Management of Environmental Issues. Students research how various environmental issues are being managed in New Jersey using a regional "systemic" approach. Examples of such an approach include the following:

- watershed management
- the Ozone Transport Commission
- the Pinelands
- management of the Delaware Bay, Barnegat Bay, and Great Egg Harbor Estuary Program

Afterwards, the students present their findings to the class.

Related Science Standards: 1, 2, 4
Related Workplace Readiness Standards: 1.3, 1.6, 2.2, 3.4